A Guide to the Marine Flora and Fauna of the Bay of Fundy and Scotian Shelf: Larval Decapoda:Brachyura

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A GUIDE TO THE MARINE FLORA AND FAUNA OF THE BAY OF FUNDY AND SCOTIAN SHELF: LARVAL DECAPODA:BRACHYURA

by

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This is the one hundred and seventy-sixth Technical Report from the Biological Station, St. Andrews, New Brunswick

PREFACE

This Technical Report is part of a series originating at the St. Andrews Biological Station entitled "Guide to the Marine Flora and Fauna of the Bay of Fundy." The series will consist of original and/or adapted, illustrated manuals on the identification, distribution and general biology of the estuarine and marine animals and plants occurring in the Bay of Fundy-Scotian Shelf region.

The series is a continuation and expansion of "A Preliminary Guide to the Littoral and Sublittoral Marine Invertebrates of Passamaquoddy Bay" and is produced under the auspices of Fisheries and Environmental Sciences to assist in environmental studies concerning the Scotia-Fundy Region. The guide is being prepared in collaboration with systematics specialists and manuals will be based as much as possible on recent revisionary systematics research. Each manual, concerning a major taxon, will include an introduction, illustrated glossary of terms, illustrated keys, alphabetic checklist and available information on distribution, habitat, life-history related biology, and references to the major literature on the group.

The series is intended for use by students and researchers wishing to identify marine organisms found in the Bay of Fundy, Gulf of Maine and on the Scotian Shelf. They are written as much as possible so that persons without systematic training may use them, and with the hope they will serve as a guide to additional information concerning a taxon. Since the Bay of Fundy-Scotian Shelf region has a wide range of physical habitats and therefore organisms, these manuals will be useful for organism identification throughout the Maritimes and may, in some cases, replace or expand the old series "Canadian Atlantic Fauna." In general, this series will be complementary to Natural History Series in progress at the National Museum of Natural Sciences, Ottawa.

Whenever possible, representative specimens dealt with in the manuals will be deposited in the reference collection of the Atlantic Reference Centre at the Biological Station, St. Andrews. Researchers in the Bay of Fundy are requested to donate to this collection series of specimens they believe should be available for future examination and reference.

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ABSTRACT

Roff, John C., Kevin G. Davidson, Gerhard Pohle and Michael J. Dadswell. 1984. A guide to the marine flora and fauna of the Bay of Fundy and Scotian Shelf: Larval Decapoda:Brachyura. Can. Tech. Rep. Fish. Aquat. Sci. 1322: iv + 57 p.

Twelve families and 31 species of larval Brachyura, as zoeas and/or megalopas from the Bay of Fundy and the Scotian Shelf, are distinguished in an illustrated dichotomous key. The key is based on original collections from the Cabot Strait to Georges Bank, and on all published descriptions of zoeas and megalopas of Brachyura known to inhabit Canadian Atlantic waters. Descriptions of three previously undescribed larvae believed to be Ethusa microphthalma (zoea only), Lyreidus bairdii (megalopa only) and Parthenope pourtalesii (megalopa only) are included.

Key words: Brachyura, larvae, zoea, megalopa, marine, identification key, Bay of Fundy, Scotian Shelf, Canada, new descriptions, taxonomy

RÉSUMÉ

Roff, John C., Kevin G. Davidson, Gerhard Pohle and Michael J. Dadswell. 1984. A guide to the marine flora and fauna of the Bay of Fundy and Scotian Shelf: Larval Decapoda:Brachyura. Can. Tech. Rep. Fish. Aquat. Sci. 1322: iv + 57 p.

Une clé dichotomique illustrée sert à séparer 12 familles et 31 espèces de Brachyura larvaires, zoés ou mégalopes ou les deux, rencontrées dans la baie de Fundy et sur le plateau Scotian. La clé repose sur des collections originales effectuées depuis le détroit de Cabot jusqu'au banc Georges et sur toutes les descriptions publiées de larves zoés et mégalopes de Brachyura connues des eaux atlantiques canadiennes. Elle comprend en outre la description de trois larves non encore décrites et qu'on croit être Ethusa microphthalma (zoé seulement), Lyreidus bairdii (mégalope seulement) et Parthenope pourtalesii (mégalope seulement).

INTRODUCTION

The infra-order Brachyura, comprising the true crabs, includes over half the order Decapoda. About 4,500 species are described worldwide; the most complete account of the adult crabs of North America is found in the volumes of Rathbun (1918, 1925, 1930, 1937).

The planktonic larvae of the Brachyura (zoeas and megalopas) are entirely marine and estuarine, and show a remarkable degree of similarity from morphologically very different parents. A good introduction to the decapod larvae is still Gurney (1942) who considers the megalopa a post-larva; the extensive accounts by Aikawa (1929, 1933, 1937) are also useful. Indispensable recent reviews are those by Rice (1980) and Williamson (1982).

The present key is based upon two major sources of information:

1. Over 3,000 plankton collections of larval Brachyura taken during the summers of 1977 and 1978 from the Scotian Shelf, Cabot Strait to Georges Bank and including the outer Bay of Fundy to Grand Manan;

2. Published descriptions of the larvae of all species known to inhabit this region of Atlantic Canada as adults. Also included are those larval species found in or believed to occur in the plankton of Atlantic Canada, but which may not be present as adults (e.g. expatriate larvae of more southern adults). The key is in two parts, covering zoeas in the first part and megalopas in the second. It does not include prezoeas which occur in some species.

Emphasis here has been placed on distinguishing those species of commercial or potentially commercial significance in Canada from the species with which they could be confused. These include Cancer borealis and C. irroratus, Chionoecetes opilio, Geryon quinquedens, and Hyas araneus and H. coarctatus.

Identification of some species included here is tentative, because the larvae of many East Coast Brachyura are not yet described. Positive identification of zoeas and megalopas of a species can only be achieved where descriptions of laboratory reared specimens are available. Because of the dearth of information however, we considered it important to include both likely and positive identifications.

Where scientific reliability is essential, identifications of specimens should be cross-checked to the original description (see References), recalling that there may be differences in precise setation patterns between field and laboratory specimens.

The collections of specimens upon which this key is partly based are housed in the Atlantic Reference Centre at the Biological Station, St. Andrews, N.B., and with Dr. J.C. Roff, Zoology Department, University of Guelph, Ontario.

PRESERVATION OF SPECIMENS AND PRECAUTIONARY NOTES

There are few problems in preserving larval Brachyura. A 4 to 5% solution of formaldehyde (~ 10:1 dilution of formalin) is adequate for initial preservation. For longer storage, specimens may be easier to handle and manipulate if preserved in 70% ethyl alcohol.

Individual appendages will often need to be dissected from the body to help identification. Mounting appendages under a cover slip in a water miscible medium, such as Turtox low viscosity medium containing acid fuchsin, is preferred. Acid fuchsin rapidly stains the appendages and makes detailed examination of setation much easier.

Characteristics of antennae and antennules are especially important in the taxonomy of larval Brachyura. Preparations should be examined very carefully for possible missing setae or aesthetascs. Their insertions can always be seen in stained preparations, but may be missed in unstained preparations.

The number of setae on a given appendage can be variable within a species, especially in the mouthparts and pleopods. Numbers of setae on specimens from field collections often do not agree with published accounts of laboratory reared specimens. The tendency appears to be for laboratory reared specimens to show fewer setae on a given appendage than field specimens. This is a preliminary statement of a problem which requires fuller investigation.

Notes on chromatophore patterns apply to living species and are apt to degrade or vary in preserved specimens.

STAGES OF BRACHYURAN DEVELOPMENT

Eggs are carried by a berried female beneath the reflexed abdomen, often for considerable periods of time. Hatching usually takes place into a first zoeal stage, but in some species eggs may hatch into a prezoea.

The prezoea is easily distinguished from zoeal stages because it is still enclosed within a cuticle which forms simple sheaths around the maxillipeds. The maxilliped setae are therefore not apparent.

The number of zoeal stages which occur is quite variable between species (see Appendix 2), and there does not seem to be any useful generalization to be made on this point. Even within a species the number of stages can vary (e.g. 6-8 in Callinectes sapidus).

Although claims have been made that more than one megalopa stage may occur in some species, laboratory studies on North American Brachyura only show only one megalopa stage.

Differentiation of Brachyuran zoeas and megalopas from other decapod larvae should become apparent from the key, Appendix 3, and the glossary.

The megalopa molts into a 1st crab stage which in successive molts takes on the characteristics of the adult. Megalopas and early crab stages can be distinguished by the following characteristics:

	Megalopa	Crab stages
1.	Abdomen generally held out posteriorly from body	Abdomen generally reflexed beneath body
2.	Abdomen rounded in cross-section	Abdomen flattened in cross-section
3.	Pleopods well developed and setose, used for propulsion	Pleopods progressively degenerate in time; not used for propulsion
4.	Different from adult body shape	Progressively develop adult characteristics

GLOSSARY

ABDOMEN - the segmented hindmost part of the body consisting of six somites and telson; in zoeal stages the sixth abdominal segment may be fused with the telson so that only five somites are evident (Fig. 1).

AESTHETASC (AESTHETE) - thin walled, tubular, non-tapering sensory receptor (seta) on the antennule (Fig. 3).

ANTENNA (SECOND ANTENNA) - the second pair of segmented cephalic sensory appendages in Crustacea (Fig. 2, 4, 5).

ANTENNAL SCALE - a large, expanded and flattened antennal exopodite found on the antennae of some non-Brachyuran decapod larvae and adults (Fig. 5).

ANTENNULES - the first pair of cephalic appendages (Fig. 1, 3).

BASAL ENDITE - the second most proximal lobe of the maxilla and maxillule, often deeply bifurcated on the maxilla (Fig. 6).

CARAPACE - the exoskeletal, shield-like cephalic outgrowth which covers at least part of the anterior dorsal surface and the lateral portions of the ventral surface of the cephalothorax; often produced into dorsal, lateral or rostral spines (Fig. 1, 7) in decapod larvae.

CEPHALIC - pertaining to the head.

CEPHALOTHORAX - consisting of head segment (cephalon) and one or more trunk (thorax) segments.

CHELA (CLAW OR HAND) - the last two segments of a cheliped. The movable finger is the dactylus and the propodus is comprised of the fixed finger and manus or palm (Fig. 8).

CHELIPED - first pair of pereiopods (ninth pair of appendages), usually stouter than other pereiopods, the last two segments forming a claw (Fig. 7, 8).

CHROMATOPHORES - star shaped or branched pigment-bearing cells.

COXAL ENDITE - the first or most proximal lobe of a maxillule or maxilla, often deeply bifurcated in the latter (Fig. 6).

ENDOPODITE - the inner branch of a biramous appendage (Fig. 1).

EPIPODITE - lateral process attached to protopodite.

EXOPODITE (EXOPOD) - the outer branch of a biramous appendage, suppressed in all the pereiopods of the megalopa which are uniramous (Fig. 1, 4).

FURCA - the forked end of the abdomen in zoeal stages (Fig. 2).

MANUS (PALM) - the proximal part of the propodus of the cheliped (Fig. 8).

MAXILLA (SECOND MAXILLA) - fifth pair of appendages; third pair of mouthparts.

MAXILLIPEDS - sixth to eighth pair of appendages; the three most posterior pairs of mouthparts (Fig. 2).

MAXILLULE (FIRST MAXILLA) - fourth pair of appendages; second pair of mouthparts.

MEGALOPA (MEGALOPS) - according to Gurney (1942), the first post-larval stage of Brachyura; pereiopods are developed and segmented, the first one is chelate, pleopods are developed and function as locomotory organs (Fig. 7).

METANAUPLIUS - larval stage succeeding the nauplius stage and basically similar to it except that the body is elongated and segmented.

NAUPLIUS - the earliest larval stage of Crustacea; body shows no segmentation; antennules, antennae and mandibles only are present; a single simple median nauplius eye may be present (Fig. 9).

PEREIOPODS - ninth to thirteenth pair of appendages; the chelipeds plus four pairs of walking legs.

PHYLLOSOMA - the characteristic flattened transparent larval phase of the Scyllaridea, with long maxillipeds and legs (Fig. 10).

PLEOPODS - fourteenth to eighteenth pair of appendages on the first to fifth abdominal somites (Fig. 7).

PLUMOSE - feathery; a seta with lateral setules emanating from shaft.

PREZOEA - the larva of a Brachyuran when first hatched and still covered by the embryonic cuticle; endopodites and exopodites of maxillipeds especially are surrounded by sheaths and bear no external setae.

PROPODUS - second to last segment of endopodite.

PROTOPODITE - the first or basal segment of an arthropod limb; especially here the basal or first segment of the antenna (Fig. 4).

PROTOZOEA - applied to the post-nauplius stages of Penaeidea and the last embryonic stage of other Decapoda (Fig. 11, 12).

RAMUS (Pl. RAMI) - a branch of any branched limb; thus a biramous limb is divided into exopodite and endopodite; a uniramous limb has only one branch.

ROSTRUM - anterior median extension of the carapace often forming a distinct spine or spines (Fig. 1, 7).

ROSTRAL SPINE - see rostrum.

SETA - a bristle, spine- or hair-like structure, with basal socket, and produced as an extension of the cuticle; mostly on appendages; setal shaft may be smooth (simple seta), or feathery and bear setules (plumose seta).

SETOSE - bearing setae.

SETULE - a fine hair or thread borne on shaft of a seta.

SCAPHOGNATHITE (BAILER) - epipodite of the (second) maxilla which regulates water flow past the respiratory surface.

SOMITE - a segment of the body, not of the appendage.

SPINE - direct and continuous cuticular outgrowth, forming a gross morphological projection. In decapod larvae mostly on carapace but also on other structures, e.g. pereiopods, abdomen.

SPINULE - a small spine.

STERNUM - the ventral plate on an arthropod segment.

TELSON - the unpaired appendage on the hindmost abdominal somite (see abdomen).

THORAX - seventh to fourteenth somites; in Brachyura always fused with the six head somites to form a cephalothorax.

TRACHELIFER - larval stage of certain Thalassinidea which is extremely elongate in the region between antenna and mouth (Fig. 13).

UROPOD - the last pair of abdominal appendages on the sixth abdominal somite (lacking or vestigial in adult Brachyura) (Fig. 11).

ZOEA - properly applied to larval stages of Brachyura only (Gurney 1942); abdomen is segmented, pereiopods and pleopods absent, or present as buds in later stages; pair of compound eyes present, propulsion by means of thoracic maxillipeds (Fig. 1, 2).

Generalized Features of a Decapod Larva

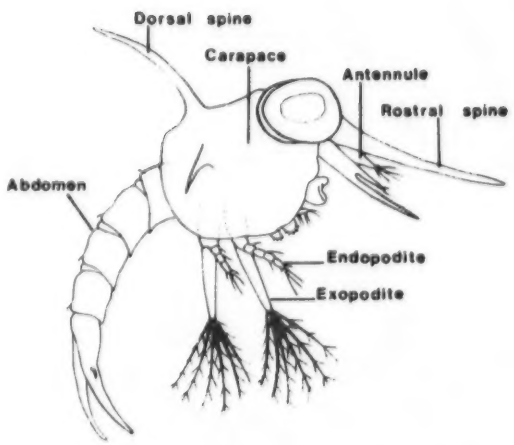


Fig. 1. Generalized zoea, lateral view.

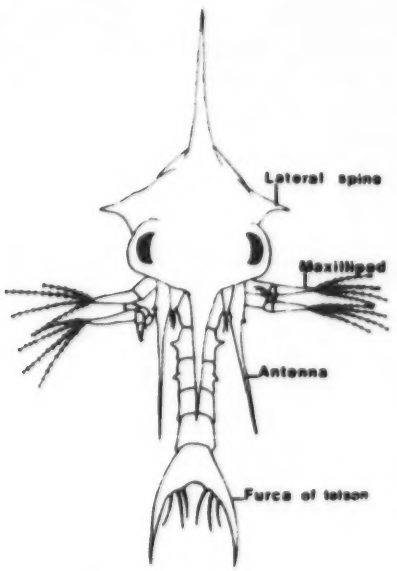


Fig. 2. Generalized zoea, frontal view.

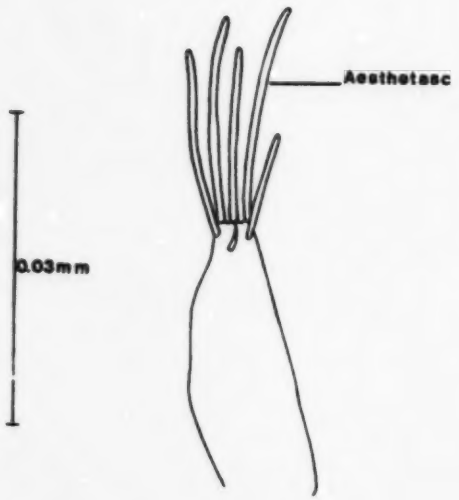


Fig. 3. Zoea, antennule (after Sastry 1977b).

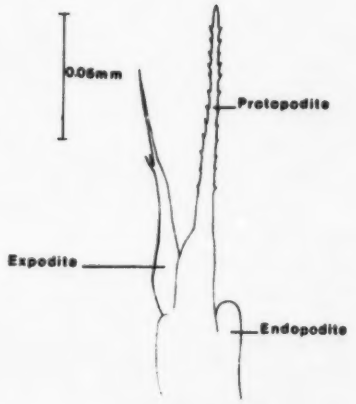


Fig. 5. Antenna, Galathea rostrata (after Gore 1979).

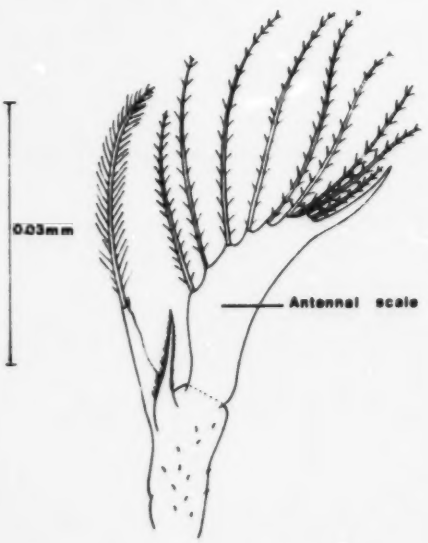


Fig. 4. Zoea, antenna.

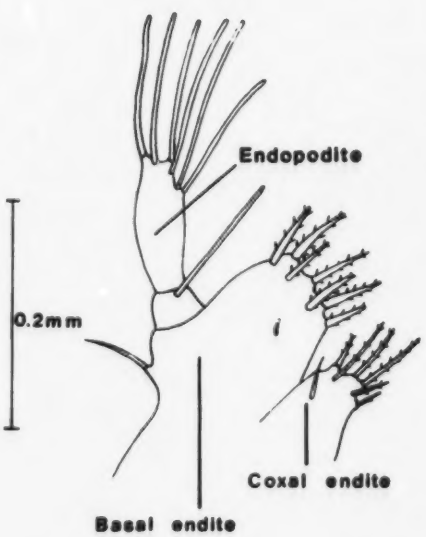


Fig. 6. Maxillule Cancer irroratus, zoea 3 (after Sastry 1977b).

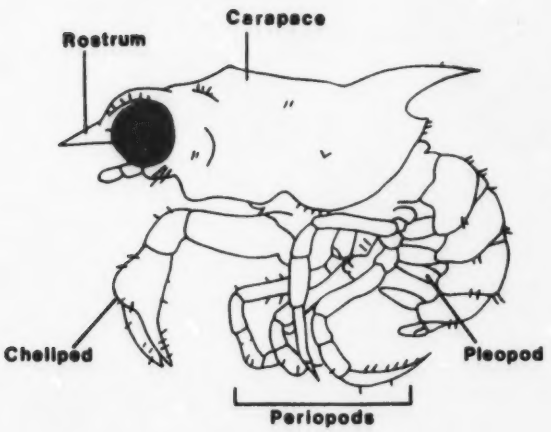


Fig. 7. Generalized megalopa lateral view.

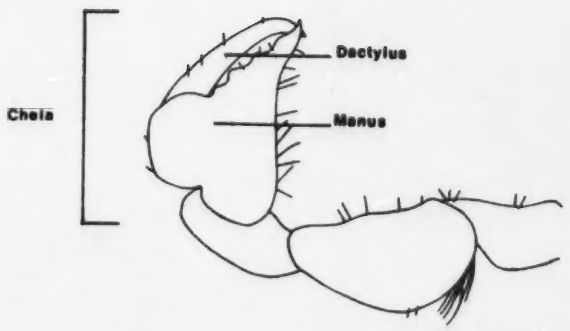


Fig. 8. Megalopa cheliped.

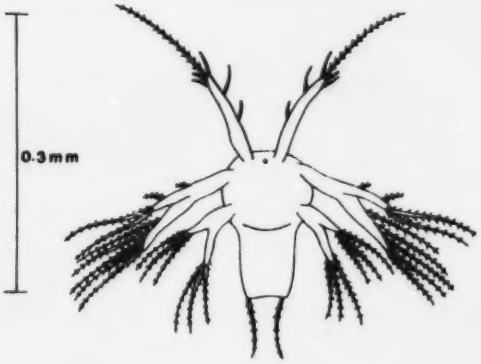


Fig. 9. Nauplius larva.

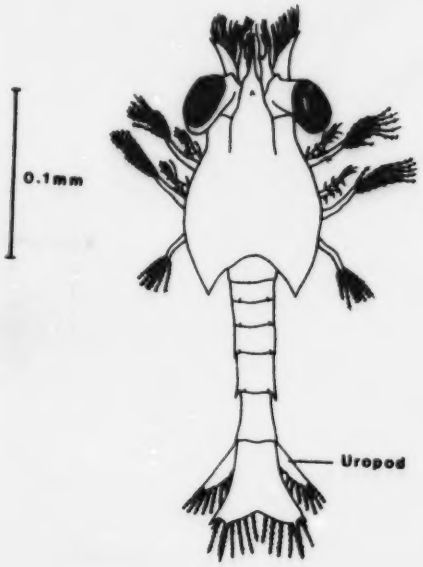


Fig. 11. Galathea rostrata, zoea 3 (after Gore 1979).

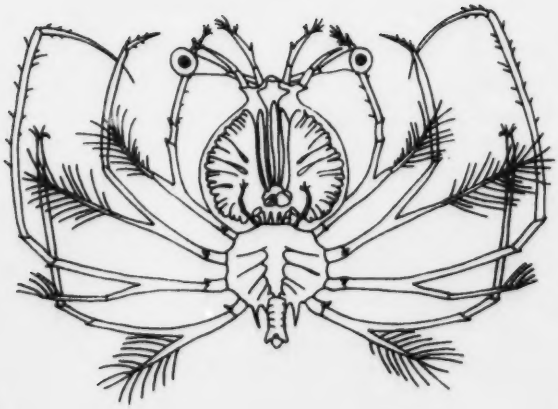


Fig. 10. Palinurus (Scyllaridea) zoea 3 (Phyllosoma) (after Gurney 1942).

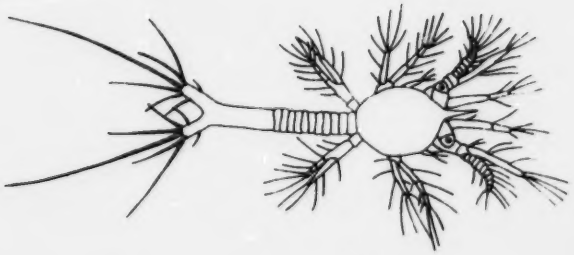


Fig. 12. Gennada sp. (Penaeidea) zoea 3 (after Gurney 1942).

Fig. 13. Jaxea sp. (Thalassinidae) zoea 2 (Trachelifer) (after Gurney 1942).

ARTIFICIAL KEY TO THE LARVAL BRACHYURA OF THE SCOTIAN SHELF REGION

1a. First three pairs of cephalic appendages setose; other appendages absent or rudimentary; nauplius eye usually present (Fig. 9) . . . . . Nauplius, Metanauplius

1b. Setose exopods on some or all thoracic appendages; pleopods absent or rudimentary in early stages; compound sessile or stalked eyes present (Fig. 1, 2, 11, 12) . . . . . Zoeas (and related developmental stages) 2

1c. Pleopods developed and setose; pereiopods well developed and segmented, first pereiopod chelate; compound stalked eyes present (Fig. 7) . . . . . See Megalopa key

2a. Dorso-ventrally flattened; transparent; a phyllosoma (Fig. 10) . . . . . Scyllaroidea

2b. Not a phyllosoma 3

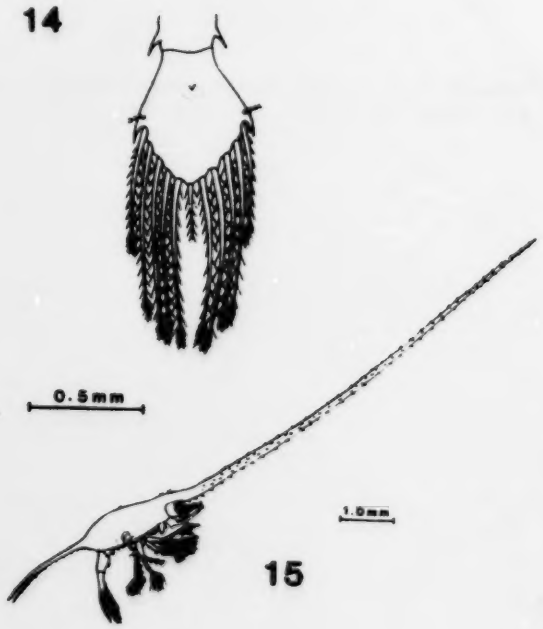
3a. Long "neck" between antennae and mouth; a trachelifer (Fig. 13) . . . . . Thalassinidea

3b. Not a trachelifer 4

4a. Antennal exopod segmented throughout its length; telson with two cylindrical rami (Fig. 12) . . . . . Protozoea of Penaeoidea and Sergestoidae

4b. Antennal exopod unsegmented, or only segmented distally in later zoeas; telson flattened or with tapering rami (Fig. 1, 2, 4, 14, 15) 5

Fig. 14. Petrolisthes armatus, telson, zoea 2.
Fig. 15. Petrolisthes armatus, zoea 2 (after Gore 1969).



5a. Carapace longer than breadth or depth; rostrum pointing forward, or absent in stage one only (Fig. 11) 6

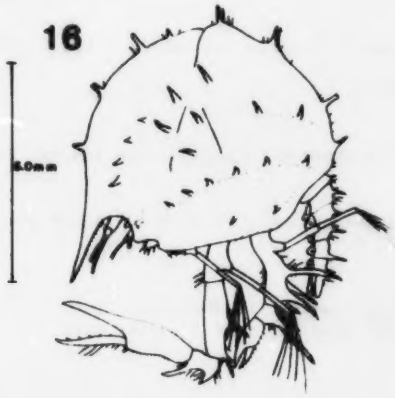
5b. Carapace sub-spherical, usually with spines; rostrum pointing ventrally or absent (Fig. 1, 2, 16) 7

6a. Carapace with stout forward-pointing rostral spine and 2 postero-lateral spines; telson broad and flat; uropods developed in later zoeas; flattened antennal scale may be present, bearing 8 or more setae (Fig. 11, 14, 15) . . . . . Anomura (Porcellanidae, Galatheidae, Paguridae) (See Appendix 3)

6b. Not with above combination of characters . . . . . Other groups (See Williamson (1957))

7a. Carapace with more than 20 spines; legs 1 and 2 chelate (Fig. 16) . . . . . Eryonidae

Fig. 16. Eryoneicus sp. zoea 3 (after Gurney 1942).



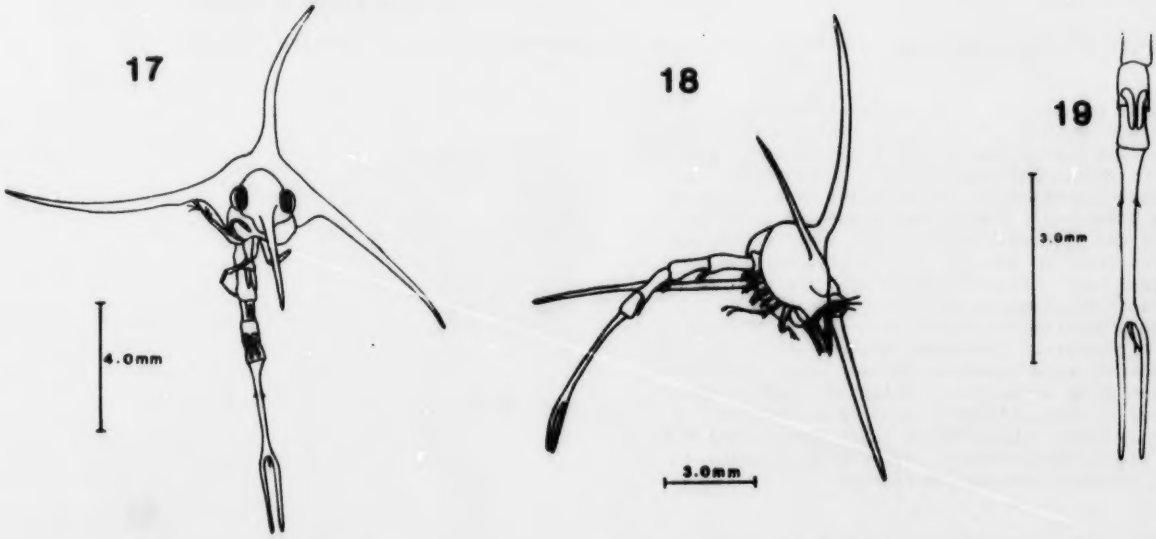
7b. Carapace with not more than 4 spines (rostral, dorsal, 2 lateral); only 1st and 2nd maxillipeds developed and setose, not chelate; telson forked (Fig. 1, 2) . . . . . Brachyura 8

8a. Very large zoeas, over 10 mm total length; very long telson furcae; ratio: length of telson/distance between tips of furcae greater than 4:1; all carapace spines longer than carapace length (Fig. 17, 18, 19) . . . . . Dorippidae, tentatively assigned to Ethusa microphthalma Smith, 1881 (larvae not described)

Distribution - Adults - Off Martha's Vineyard, Mass., to west Florida and Cuba. Larvae - to Scotian Shelf.

Fig. 17-19 Ethusa microphthalma

Fig. 17. Zoea unknown stage frontal view
Fig. 18. Zoea unknown stage lateral view
Fig. 19. Abdomen, frontal view, zoea unknown stage.



8b. Smaller zoeas, less than 7 mm total length; telson furcae not so elongate; ratio less than 2:1 9

9a. Exopodites of 1st and 2nd maxilliped armed with 4 plumose setae; no pleopods present (or as small bumps only) (Fig. 2) . . . . . Stage 1 zoeas 10

9b. Exopodites of 1st and 2nd maxilliped armed with 6-19 setae (Fig. 1); pleopod buds present in later stages . . . . . Stage 2-7 zoeas 11

10a. Larger stage 1 zoea, usually >0.8 mm carapace length; dorsal, rostral spines and antennal protopodite and telson furcae setose or armed with spinules; dorsal spine usually straight (Chionoecetes, Hyas); lateral spines held straight out or elevated upward in frontal view; abdomen held straight down below carapace or reflected dorsally (2 zoeas + prezoea) (Fig. 21, 27, 30) . . . . . Oxyrhyncha (part) 12

10b. Smaller stage 1 zoea, usually <0.7 mm carapace length; usually only antennal protopodite may be armed with spinules; dorsal spine usually curved posteriorly; lateral spines usually curve down in frontal view; abdomen often held straight down below carapace or reflected forward (more than 2 zoeas + prezoea) (Fig. 1, 2, 37, 55) . . . . . Brachyrhyncha (mainly) and Oxystomata 15

11a. Zoea with exopodites of 1st and 2nd maxilliped with 6 setae; non-functional pleopods present; large zoeas (Fig. 20, 25, 29, 32) . . . . . Stage 2 zoeas Oxyrhyncha 12

b. Zoea with exopodites of 1st and 2nd maxillipeds usually:

6 setae, no pleopods . . . . . Stage 2 zoea
8 setae, no pleopods . . . . . Stage 3 zoea
10 setae, pleopods as bumps . . . . . Stage 4 zoea
12 setae, non-functional pleopods present . . . . . Stage 5 zoea

(N.B. up to 8 zoea, e.g. Callinectes and up to 19 setae e.g. Geryon may occur) . . . . . Brachyrhyncha and Oxystomata 15

12a. Rostral spine very short, shorter than antennae and about same length as antennules; dorsal spine shorter than carapace depth, curved posteriorly; no lateral spines (Fig. 20) . . . Stage 2 zoea . . . . . Libinia emarginata Leach, 1815

(N.B. only expected local species in this genus; see Appendix 4 for other possible species).

Two zoeal stages. Duration of development at 20°C and 30 o/oo from 1st zoea to 1st crab was 14 d. Length from tip of rostral to dorsal spine of 1st zoea ~1.12 mm, 2nd zoea ~1.16 mm. Sparsely pigmented chromatophore color ranges from orange to a dark brown-red. Distinctive pigments: an orange spot at the posterior dorsal spine base, a deep red area posterior to the eye, a large red spot on the postero-lateral carapace region near the carapace setae and red pigmentation of the mandibles. Abdomen pigmented in central ventral area of each segment juncture. Additional pigment spots occur on carapace and appendages but do not appear consistent in location or occurrence. Ovigerous females were observed in Cobequid Bay in late July; Gulf of Mexico in July. Distribution - St. Mary's Bay and Minas Basin, Nova Scotia. Cape Cod to southern Texas, Bahamas, Cuba and California.

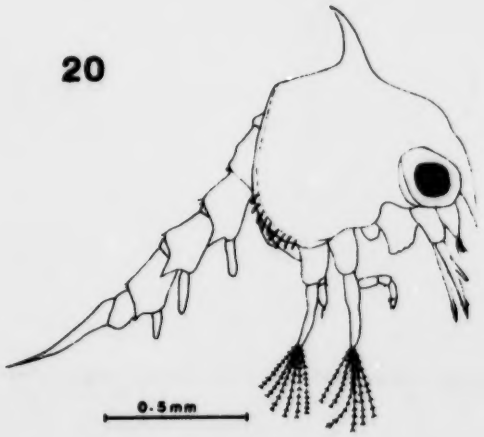


Fig. 20. Libinia emarginata, lateral view, zoea 2 (after Johns and Lang 1977).

12b. Dorsal and rostral spines longer than carapace depth, straight; lateral spines present . . . 13

13a. Dorsal, rostral and lateral spines and antennal protopodite covered with spinules; distance from tip of dorsal spine to tip of rostral spine usually ≥4.6 mm in zoea 1, and ≥5.9 mm in zoea 2 (N.B. sizes may vary between geographical areas); lateral spines of (visible) abdominal segments 2, 3 and 4 extend beyond end of next segment in zoea 1 and 2 and may bear very fine spinules. In zoea 1 antennal exopodite ends in three unequal setae, the shortest is usually about 1/2 as long as the longest. In zoea 2 antennal exopodite ends in three setae of unequal length in the ratio of approximately 1:2:4 (Fig. 21-26) . . . . . Chionoecetes opilio (O. Fabricius, 1780)

Duration of development at 6-11°C and 27.9-31.9 o/oo from hatching to 1st crab larvae stage was 71 d. Both zoeal stages appear transparent with black eyes and black internal organs. Dark brown or black chromatophores may be present ventrally on the abdominal somites or on the distal tips of the basis of the maxillipeds. Ovigerous females in Gulf of St. Lawrence and off Cape Breton observed throughout the year. Distribution - From west Greenland, southward to Casco Bay, Maine; from Arctic Alaska to Siberia, and southward through Bering Strait to the Aleutian Islands and to Korean Sea off Japan.

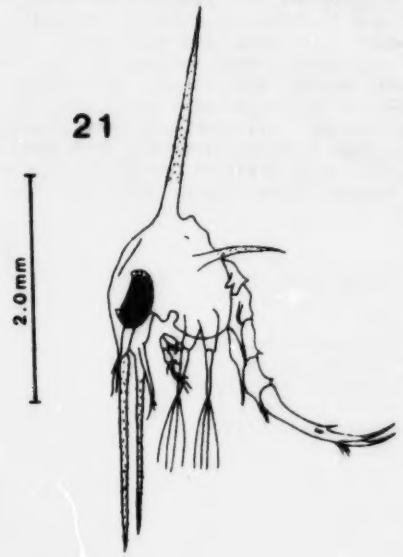
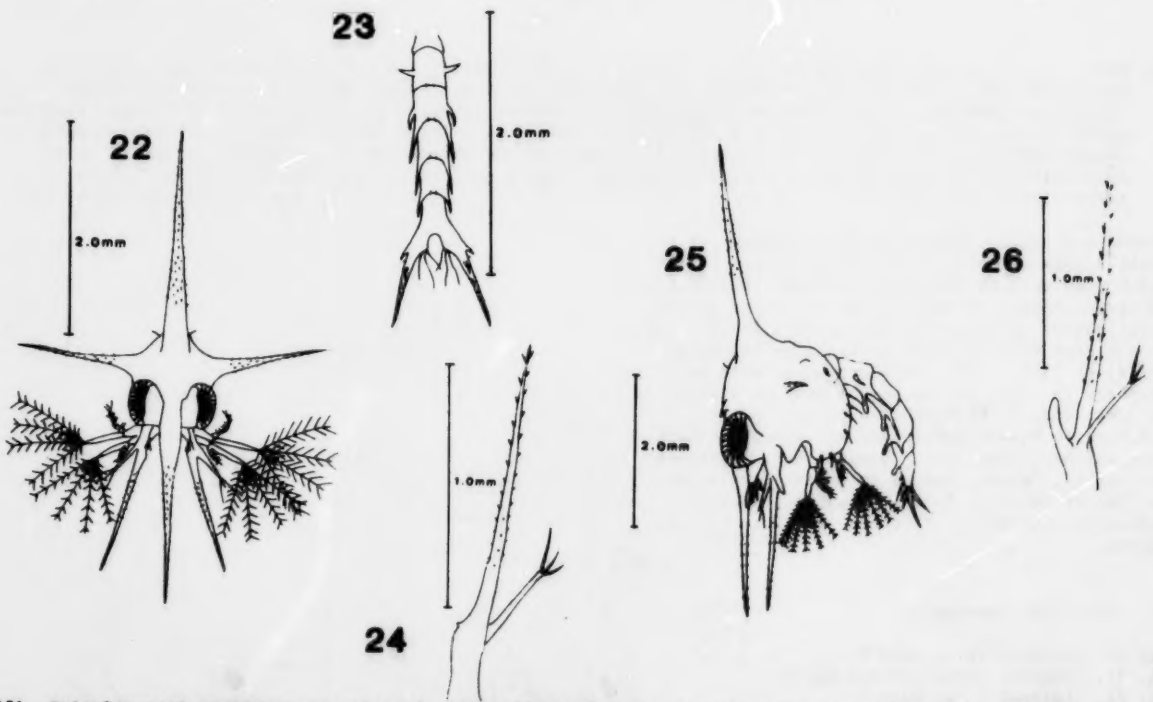


Fig. 21-26 Chionoecetes opilio.

Fig. 21. Lateral view, zoea 1.
Fig. 22. Anterior view, zoea 1.
Fig. 23. Abdomen, dorsal view, zoea 1.
Fig. 24. Antenna, zoea 1.
Fig. 25. Lateral view, zoea 2.
Fig. 26. Antenna, zoea 2.

(Fig. 22, 24, 25, 26 after Motoh 1973).
(Fig. 21, 23 after Kurata 1963).



13b. Spinules most prominent on antennal protopodite, although dorsal, rostral and lateral spines may also bear fine spinules; distance from tip of dorsal spine to tip of rostral spine usually ≤4.3 mm in zoea 1 and ≤5.1 mm in zoea 2; lateral spines of abdominal segments 2, 3 and 4 do not reach, or only just reach end of next abdominal segment, and do not bear spinules. In zoea 1 antennal exopodite ends in three unequal spines, the shortest is usually about 1/3 or less as long as the longest. In zoea 2 antennal exopodite ends in three spines of unequal length in the ratio of approximately 1:3:6 (Fig. 27-32) . . . . . genus Hyas 14

14a. Zoea 1 total length, from tip of rostral spine to tip of dorsal spine, about 4 mm (range 3.8–4.3 mm); branched orange or reddish chromatophores at base of and posterior to dorsal spine may be present; all spinules on rostral spine small. Zoea 2 total length, from tip of rostral spine to tip of dorsal spine about 4.8 mm (range 4.6–5.0 mm); red chromatophores on lateral surface of carapace posterior to dorsal spine may be present; in dorsal view lateral abdominal spines of somites 3 and 4 do not reach beginning of somites 5 and 6 respectively (Fig. 27–29) . . . . . Hyas araneus (Linnaeus, 1758)

Duration of development at 10°C and 31.5–33 o/oo from hatching to 1st crab was 65 d: at 15°C, 57 d; at 6–11°C and 27.9–31 o/oo, 59.6 d. Brownish-orange with brownish-black eyes, red near margin. Dark-orange chromatophores near the base of the antennal protopodite, on the carapace near the base of the maxillipeds and on the ventral surface of the abdominal somites. Distribution – West coast of Greenland, from Labrador at Hebron, southward to Rhode Island. East coast of Greenland, Iceland, northern Europe, Arctic Ocean, Atka, Aleutian Islands.

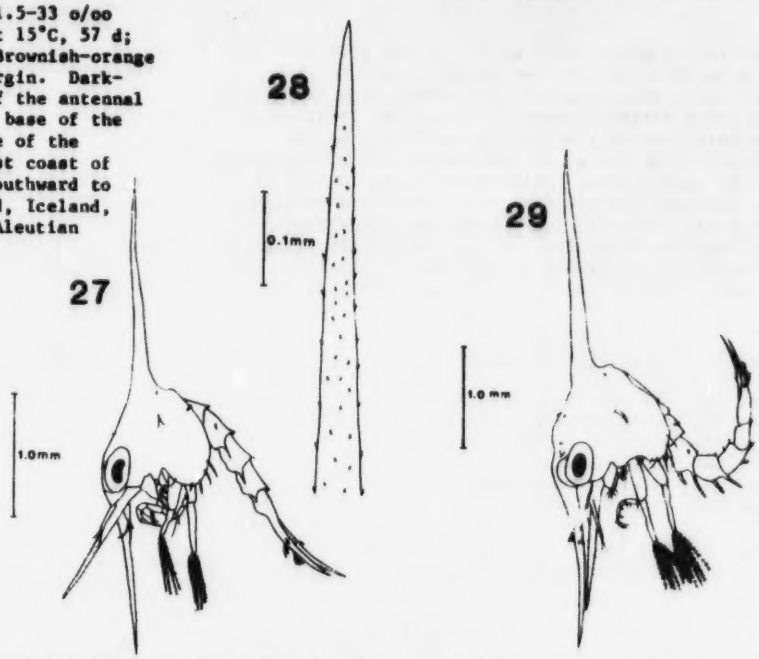


Fig. 27–29 Hyas araneus.

Fig. 27. Lateral view, zoea 1.
Fig. 28. Rostral spine, distal view.
Fig. 29. Lateral view, zoea 2.

(After Christiansen 1973).

14b. Zoea 1 total length, from tip of rostral spine to tip of dorsal spine, about 3.3 mm (range 3.2–3.4 mm); unbranched red chromatophores at base of and posterior to dorsal spine; spinules on carapace spines stouter and distally longer than in H. araneus; most distal spinules on rostral spine are longer than the width of the rostral spine at their point of insertion; Zoea 2 total length, from tip of rostral spine to tip of dorsal spine, about 3.9 mm (range 3.7–4.0 mm); no red chromatophores posterior to dorsal spine; in dorsal view lateral abdominal spines of somites 3 and 4 just reach beginning of somites 5 and 6 respectively (Fig. 30–32) . . . . . Hyas coarctatus Leach, 1815

Larvae in plankton chiefly in early spring. Eggs bright orange changing to an orange-brown. Early eggs 0.4 mm across; late eggs 0.56 mm. Few punctate red chromatophore at base of and posterior to the dorsal spine. Duration of development at 10°C and 31.5–33 o/oo from hatching to 1st crab larvae was 75.7 d; at 15°C, 46 d. Chromatophores seem to disappear in older 1st zoeae and are not visible in 2nd zoeal stage. Distribution – East and West Greenland to Hudson Strait and Bay, south to Cape Hatteras, North Carolina. Langton Bay. Northwest Territories, Canada, Alaska to Bering Strait and Sea, Sea of Japan to Korea. Shanghai, Amoy. Iceland, Arctic Coast of Europe, northern Europe, Siberia.

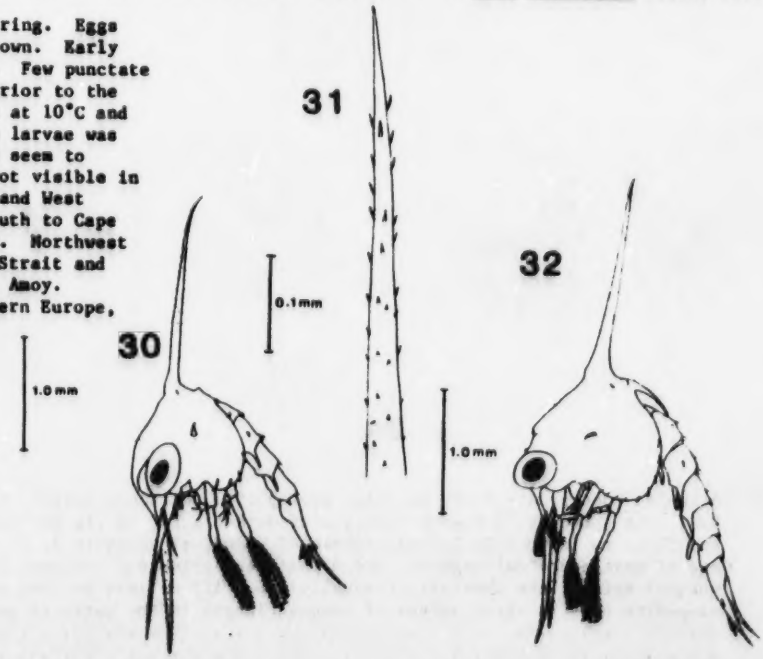


Fig. 30–32 Hyas coarctatus.

Fig. 30. Lateral view, zoea 1.
Fig. 31. Rostral spine, distal view.
Fig. 32. Lateral view, zoea 2.

(After Christiansen 1973).

15a. Carapace without dorsal and lateral spines; free margin of telson 3-lobed; total length 1 mm or less (Fig. 33, 34) (see Appendix 5) . . . . . Pinnotheres ostreum Say, 1817

Four zoeal stages.

The period of larval development from hatching to 1st crab was 25 d at 23°C and 20 d at 26°C. From the tip of rostral spine to tip of dorsal spine the 1st zoea measured 0.42 mm; 2nd zoea 0.57 mm; 3rd zoea 0.60 mm. Except for the brief free-swimming periods in the invasive stages, the crabs lead a parasitic existence inside oysters. Distribution - Adults - Salem, Mass., to the State of Santa Catarina, Brazil.

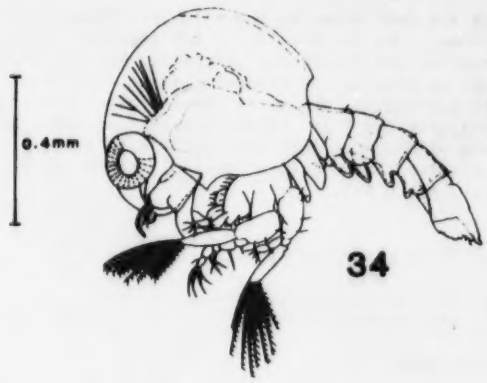
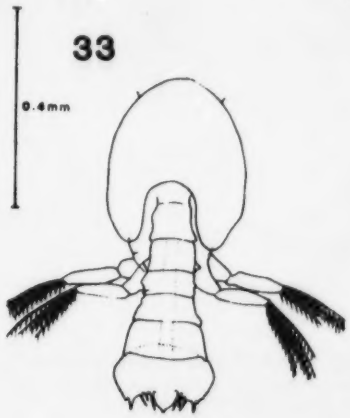


Fig. 33-34 Pinnotheres ostreum.

Fig. 33. Posterior view, zoea 1.
Fig. 34. Lateral view, zoea 3.

(After Sandoz and Hopkins 1947).



15b. Carapace with dorsal spine 16

16a. Carapace without lateral spines 17

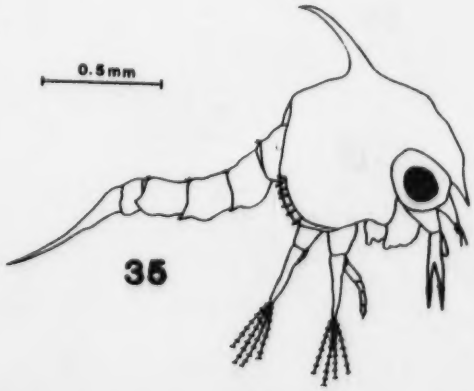
16b. Carapace with lateral spines 19

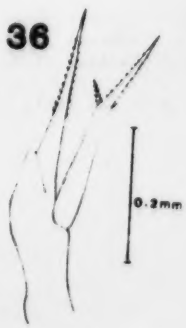
17a. Rostral spine very short, antennae much longer than rostral spine; antennal exopodite as long as protopodite (Fig. 35, 36) (Zoea, stage 1) . . . . . Libinia emarginata Leach, 1815 . . . . . .(See couplet 12 and Appendix 4)

Fig. 35-36 Libinia emarginata.

Fig. 35. Lateral view, zoea 1.
Fig. 36. Antenna, zoea 1.

(After Johns and Lang 1977).





17b. Rostral spine as long as or longer than antennae; antennal exopodite not as long as protopodite (Fig. 37, 39, 42) 18

18a. Antennae about same length as rostral spine; exopodite of antenna a turbercule with a single hair; heavily pigmented (Fig. 37, 38) (see Appendix 6) . . . . . Planes minutus (Linnaeus, 1758)

Eggs are dark brown in the mass with diameter of 0.36 mm. The 1st zoea has black pigments thickly spread on the thorax and patches on the abdomen, the whole is pale yellow appearing green. In the Carolina region, ovigerous females have been taken throughout the year. Distribution - Atlantic Ocean south of Newfoundland, west of 30°W latitude (exclusive of the Gulf of Mexico); Netherlands coast, North Sea.

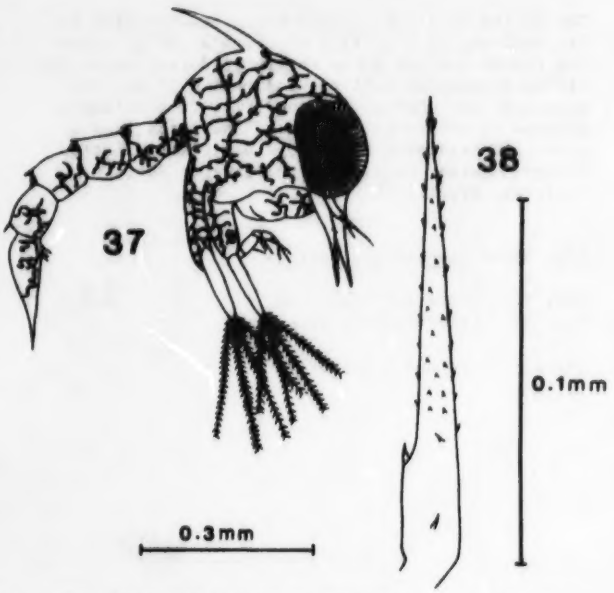


Fig. 37-38 Planes minutus.

Fig. 37. Lateral view, zoea 1.
Fig. 38. Antenna, zoea 1.

(After Hyman 1925).

18b. Antennae shorter than rostral spine; exopodite of antenna about 1/2 length of protopodite, ending in a short pointed lateral projection and bearing 2 unequal setae; red pigmentation in chromatophores along ventro-lateral margins of carapace (Fig. 39, 40, 41) . . . . . Carcinus maenas (Linnaeus, 1758)

Four zoeal stages. Development time from hatching to 1st crab stage at 12°C was 57.7 d. Length from tip of rostral spine to tip of dorsal spine of 1st zoea is 1.36-1.44 mm, 2nd 1.58-1.85 mm, 3rd 2.13-2.15 mm and 4th 2.2-2.5 mm. Eggs yellowish-brown changing to black. Early eggs 0.32 mm. Late eggs 0.4 mm across. 1st zoea greenish-brown with yellow eye blackish diffused with yellow. Many dark chromatophores, a multi-branched one along the side of the carapace which persists in the megalopa. Distribution - Atlantic coast from Bay of Fundy and outer coast of Nova Scotia to New Jersey. Brazil, Bay of Panama. Europe, North Africa; Suez Canal and Red Sea; Sri Lanka; Australia; and Hawaiian Islands. Canadian populations introduced from Europe.

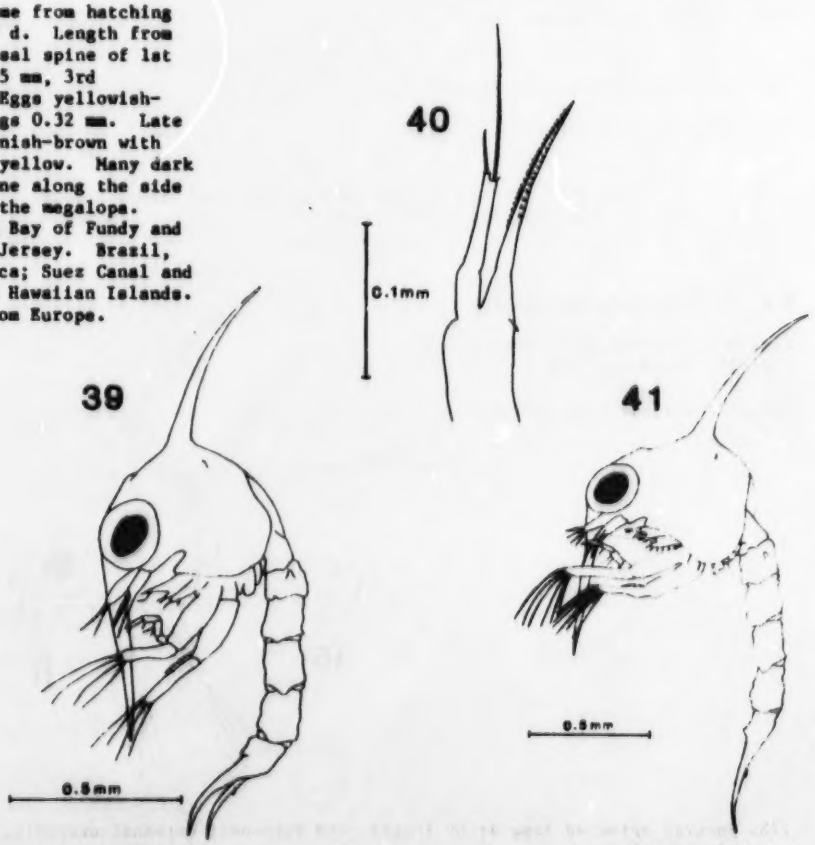


Fig. 39-41 Carcinus maenas.

Fig. 39. Lateral view, zoea 1.
Fig. 40. Antenna, zoea 1.
Fig. 41. Lateral view, zoea 2.

(After Rice and Ingle 1975b).

19a. Zoeae with small carapace (length $\leq$0.4 mm); lateral spines long and curved, arising ventrally near postero-lateral carapace margin; antennae and antennules very small, less than 1/2 length of rostral spine (Fig. 42-45) . . . . . Pinnotheres maculatus Say, 1818

Five zoeal stages. Length from tip of rostral to tip of dorsal spine of zoea 1, 2, 3, 4, 5 are 0.94, 1.24, 1.6, 1.86 and 2.06 mm, respectively. Ovigerous females can be found from July to September off Massachusetts and Rhode Island. Distribution - Adults - off Martha's Vineyard, Mass., to Mar del Plata, Argentina; Larvae - to Scotian Shelf.

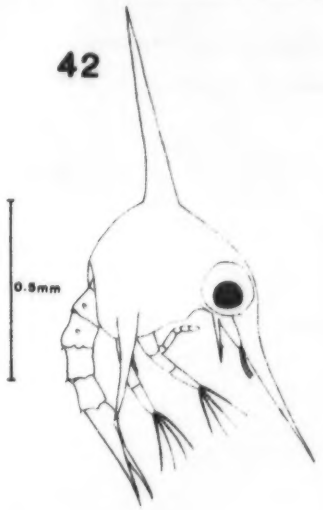
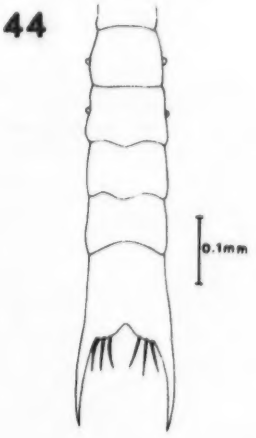
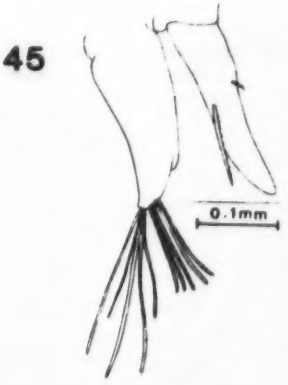


Fig. 42-45 Pinnotheres maculatus.

Fig. 42. Lateral view, zoea 1.
Fig. 43. Antennule and antenna, zoea 1.
Fig. 44. Abdomen and telson, zoea 1.
Fig. 45. Antennule and antenna, zoea 5.

(Fig. 43, 45 after Costlow and Bookhout 1966b).



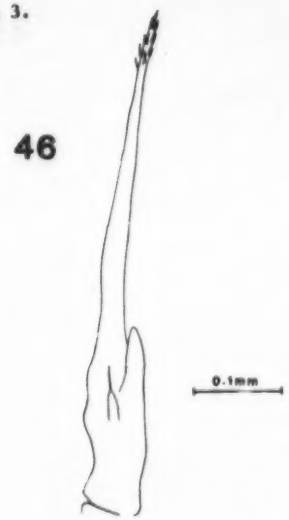


19b. Zoeae larger (carapace length $\geq$0.4 mm); lateral spines short, arising from mid-lateral carapace surface; antennae and antennules usually longer than 1/2 length of rostral spine (Fig. 47) 20

20a. Antennal exopodite minute, little more than a spine knob or bud; protopodite smooth or with spinules distally (Fig. 46) . . . . . Xanthidae, in part (Appendix 7) 21

Fig. 46. Panopeus herbstii, antenna, zoea 3.

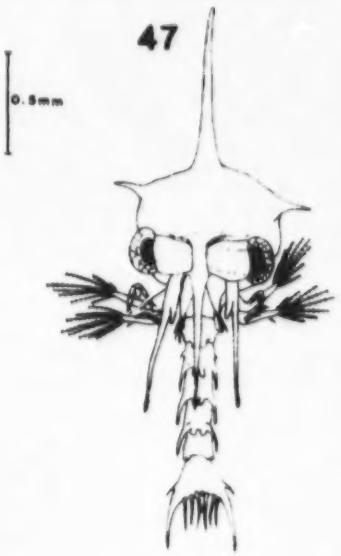
(After Costlow and Bookhout 1961a).



20b. Antennal exopodite a distinct segment or spine (although it may be very small), with terminal setae, up to about 1/2 length of protopodite; protopodite bearing one to several rows of spinules distally (Fig. 54-64) 23

21a. Dorsal, rostral and antennal spines about same length as carapace; antennal protopodite with spinules distally (Fig. 46-48) . . . . . Panopeus herbstii H. Milne-Edwards, 1834

Four zoeal stages. Larval development from hatching to 1st crab was completed in 48-52 d at 20°C, in 18-28 d at 30°C. Length from tip of rostrum to tip of dorsal spine of 1st zoea through stage 4 ranges from 1.36-2.11 mm. Melanophores are distributed in the following pattern: (1) dorsal and median to each eye; (2) posterior and slightly ventral to each eye; (3) dorsal to heart, just posterior to dorsal spine; (4) postero-lateral margins of cephalothorax; (5) mandibles and labrum; (6) first abdominal somite, median and dorsal to gut; (7) abdominal somites 2-5, postero-ventral surface; (8) basipodites of maxillipeds 1 and 2. Ovigerous females observed in July off Maryland. Distribution - Adults - Boston, Mass., to State of Santa Catarina, Brazil. Bermuda. Florida.



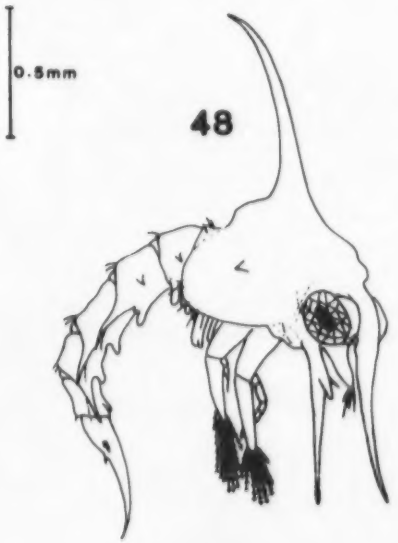


Fig. 47-48 Panopeus herbstii.

Fig. 47. Frontal view, zoea 3.
Fig. 48. Lateral view, zoea 3.

(After Costlow and Bookhout 1961a).

21b. Dorsal, rostral and antennal spines much longer than carapace; antennal protopodite smooth (Fig. 49, 51, 52) 22

22a. Rostral and antennal spines about equal in length to abdomen, dorsal spine about equal to or shorter than abdomen; telson about 1½ times as long as broad; lateral spines of fourth abdominal segment not elongate (Fig. 49, 50) . . . . . (See Appendix 8)
. . . . . Neopanope texana spp.

Four zoeal stages. Development time from hatching to megalops at 30 o/oo and 30°C was 12-14 d and at 21°C was 20-27 d. Length from tip of rostral spine to tip of dorsal spine of 1st zoea, 1.2 mm; 2nd zoea, 1.5 mm, 3rd zoea, 2.0 mm and 4th zoea, 2.5 mm. Ovigerous females observed in October in Chesapeake Bay. Distribution - Malpeque, Prince Edward Island; Geddes Point, Northumberland Strait. New Brunswick, Massachusetts to eastern Florida.

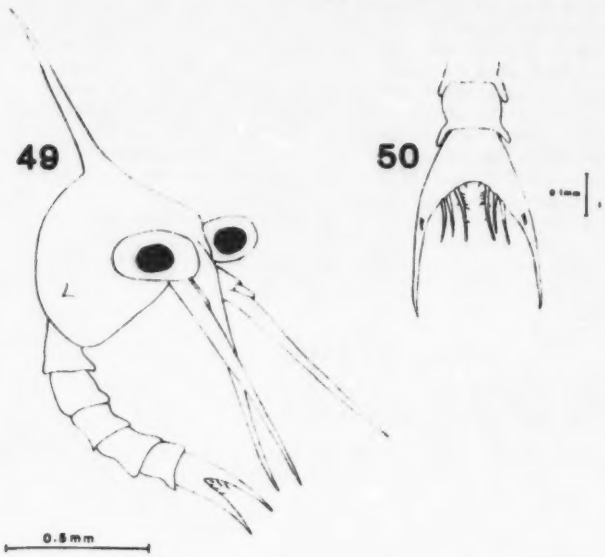


Fig. 49-50 Neopanope texana spp.

Fig. 49. Lateral view, zoea 3.
Fig. 50. Telson, zoea 2.

(After Chamberlain 1961).

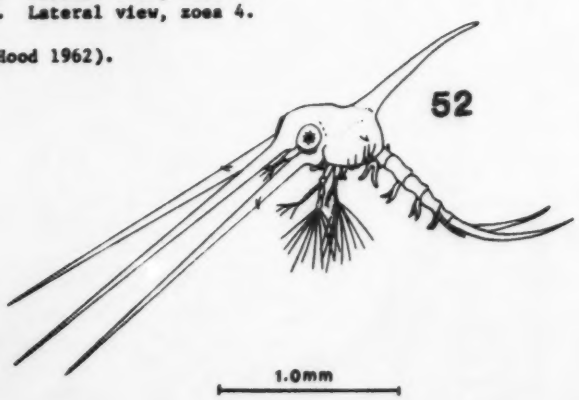
22b. Rostral and antennal spines longer than abdomen which is longer than dorsal spine; telson about 2 times as long as broad; furcae very elongate; lateral spines of fourth abdominal segment elongate (Fig. 51, 52).
. . . . . Rhithropanopeus harrisii (Gould, 1841)

Four zoeal stages. Length from tip of rostral spine to tip of dorsal spine of the 1st zoea, 2.2 mm; 2nd, 2.5 mm; 3rd, 3.4 mm; 4th, 3.8 mm. Development time from hatching to megalops at 6-10 o/oo and 15°C is 20-24 d; 24°C, 13-15 d; 30°C, 11-13 d. In Chesapeake Bay, ovigerous females are observed June to September and juveniles are found all months of the year occurring most frequently July to October. Distribution - The original range of these species was in fresh to estuarine water from western Gulf of St. Lawrence, New Brunswick, Canada, to Veracruz, Mexico; northeast Brazil. The species has been introduced on the west coast of the United States and in parts of Europe.

Fig. 51-52 Rhithropanopeus harrisii.

Fig. 51. Lateral view, zoea 3.
Fig. 52. Lateral view, zoea 4.

(After Hood 1962).



23a. Antennal exopodite 1/3 to 1/2 length of protopodite, bearing 2 or 3 terminal setae (Fig. 54, 63) 24

23b. Antennal exopodite much less than 1/3 length of protopodite, bearing 2 terminal setae (Fig. 90, 93) 30

24a. Antennal exopodite bearing 2 unequal terminal setae (Fig. 54) 25

24b. Antennal exopodite bearing 3 unequal terminal setae (Fig. 64) 26

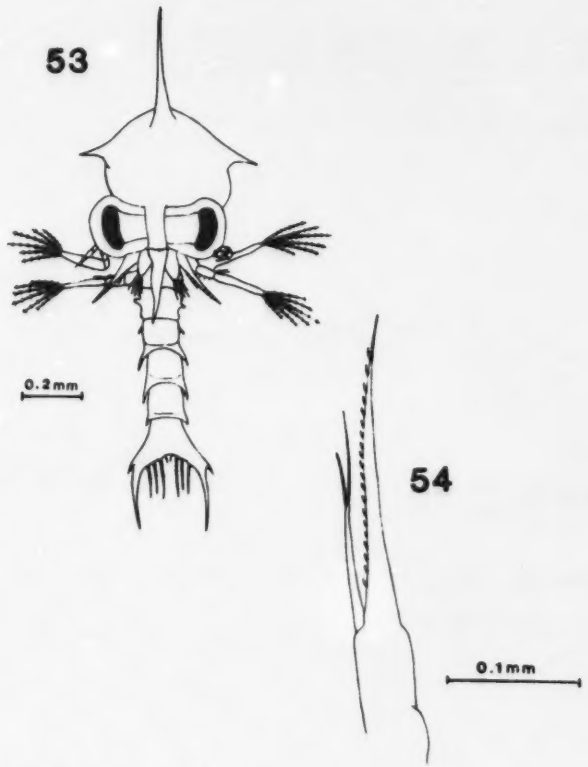
25a. Antennal protopodite bearing a single row of about 20 spinules (Fig. 53, 54) . . . . . .(see Appendix 9) . . . . . Hepatus epheliticus (Linnaeus, 1763)

Five zoeal stages. Development time from hatching to megalopa at 30 o/oo and 25°C is 21-22 d. Length from tip of rostral spine to tip of dorsal spine of the 1st, 0.87 mm; 2nd, 0.91 mm; 3rd, 1.20 mm; 4th, 1.27 mm and 5th, 1.60 mm. Locations of the melanophores are 1) posterior to the eyes, extending ventrally to the base of rostral spine; 2) ventrally to the heart, extending toward the lateral spines; 3) posterior margin of cephalothorax; 4) basipodites of the first and second maxillipeds; 5) mandibles and labrum; 6) first and second abdominal somites, dorsal to the gut; 7) poster-oventral border of abdominal somites 2-5. Distribution - accidental to Nova Scotia; Chesapeake Bay to Gulf of Campeche, Mexico; Cuba; Jamaica; Dominica Republic.

Fig. 53-54 Hepatus epheliticus.

Fig. 53. Frontal view, zoea 2.
Fig. 54. Antenna, zoea 2.

(After Costlow and Bookhout 1962a).



25b. Antennal protopodite bearing more than one row of spinules (Fig. 77) 27

26a. Zoeas with the following characters:

Zoea 1. Antennal protopodite typically shorter than rostrum (Fig. 55) (ratio of lengths about 5/6 to sub-equal); antennal protopodite length (measured from tip to point of insertion at base of eye) average 0.46 mm, range 0.43-0.47 mm; rostral spine length (in anterior view (Fig. 56) measured from tip to mid-point of eyes) average 0.59 mm, range 0.56-0.63 mm. Antennule and antenna very similar to C. irroratus (Fig. 66, 67) . . . . . Cancer borealis Stimpson, 1859)

Length from tip of rostral spine to tip of dorsal spine of 1st zoea is 1.11 mm; 2nd, 1.46 mm; 3rd, 2.01 mm; 4th, 2.31 and 5th, 3.86 mm. Distribution - Southern New Brunswick; Nova Scotia to Florida; Bermuda.

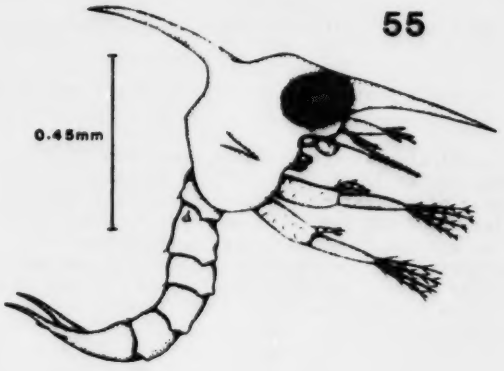
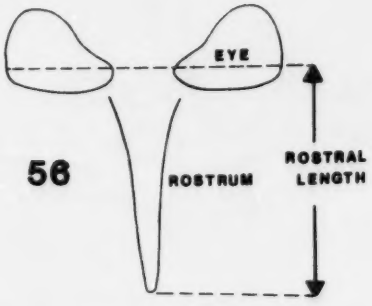


Fig. 55. Cancer borealis lateral view, zoea 1.
Fig. 56. Cancer borealis/irroratus, zoea 1 - diagram of rostral spine length.

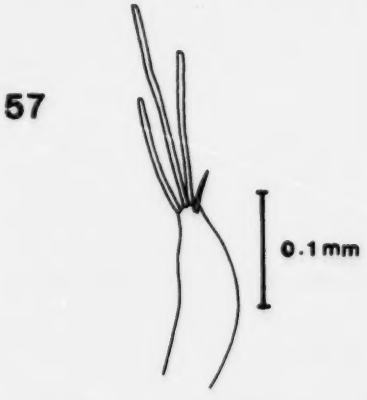
(Fig. 55 after Sastry 1977a).



Zoea 2. Antennule with 3 unequal aesthetascs and one seta (Fig. 57). Antenna very similar to C. irroratus (Fig. 69)

Fig. 57. Cancer borealis antennule, zoea 2.

(After Sastry 1977a).



Zoea 3. Maxillule basal and coxal endites with 8 and 6 setae, respectively (Fig. 58); scaphognathite of maxilla with 12 or 13 plumose setae (Fig. 59). Antennule and antenna very similar to C. irroratus.

Fig. 58-59 Cancer borealis.

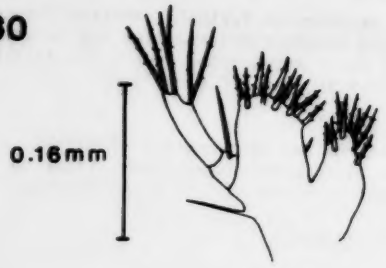
Fig. 58. Maxillule, zoea 3.
Fig. 59. Maxilla, zoea 3.

(After Sastry 1977a).

Zoea 4. Maxillule basal and coxal endites with 12 and 9 spines, respectively (Fig. 60). Antenna and antennule very similar to C. irroratus.

Fig. 60. Cancer borealis, maxillule, zoea 4.

(After Sastry 1977a).

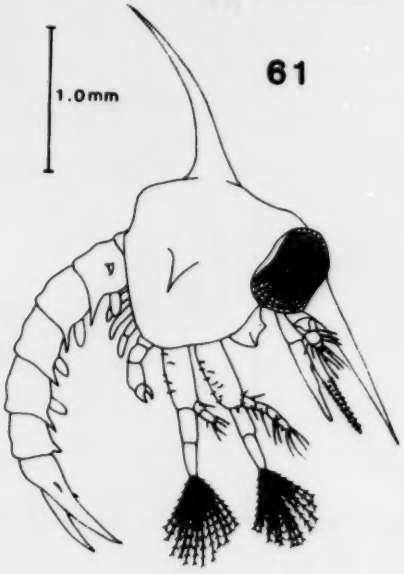


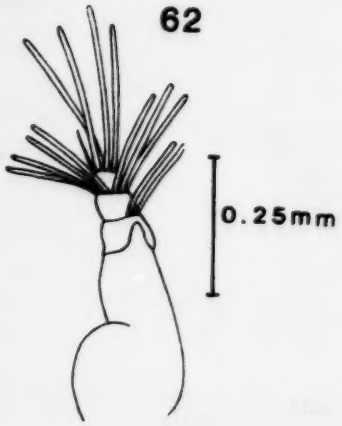
Zoea 5 (Fig. 61). Antennule segmented, with 3 tiers of aesthetascs, from proximal to distal arrangement is: 2, 7, 4, and 1 spine (Fig. 62); maxillule basal and coxal endites with 12+2 and 10 setae, respectively (Fig. 63). Antennae (Fig. 64) very similar to C. irroratus.

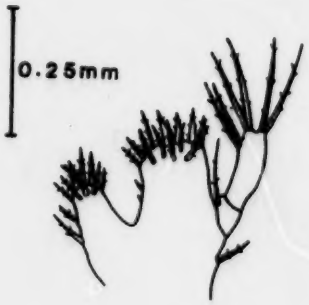
Fig. 61-64 Cancer borealis.

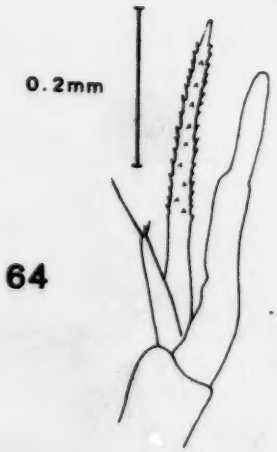
Fig. 61. Lateral view, zoea 5.
Fig. 62. Antennule, zoea 5.
Fig. 63, Maxillule, zoea 5.
Fig. 64. Antenna, zoea 5.

(After Sastry 1977a).









26b. Zoeas with the following characters:

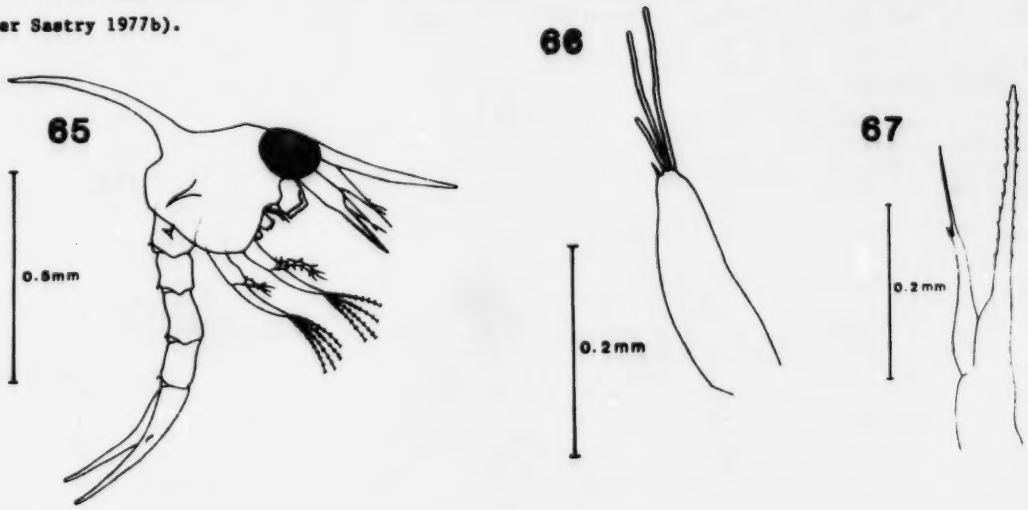
Zoea 1. Antennal protopodite typically shorter than rostrum (ratio of lengths about 2/3); antennal protopodite length (measured from tip to point of insertion at base of eye) average 0.40 mm, range 0.33-0.46 mm; rostral spine length (in anterior view (Fig. 65) measured from tip to mid-point of eyes) average 0.69 mm, range 0.65-0.73 mm . . . . . Cancer irroratus Say, 1817

Length from tip of rostral spine to tip of dorsal spine of first to fifth zoea ranges from 1.18 mm to 3.55 mm. Distribution - Labrador to South Carolina.

Fig. 65-67 Cancer irroratus.

Fig. 65. Lateral view, zoea 1.
Fig. 66. Antennule, zoea 1.
Fig. 67. Antenna, zoea 1.

(After Sastry 1977b).

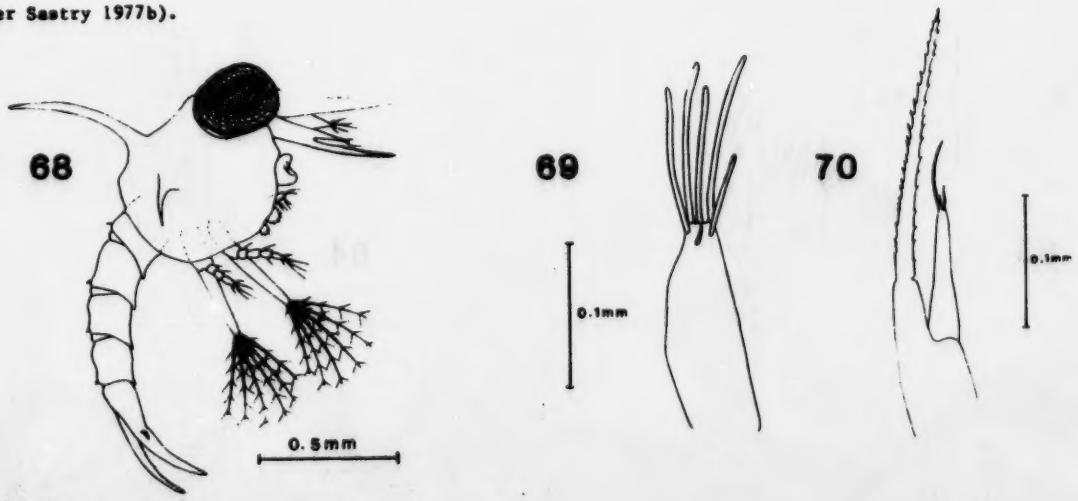


Zoea 2 (Fig. 68). Antennule with 5 unequal aesthetascs and one seta (Fig. 69). Antenna very similar to C. borealis (Fig. 70).

Fig. 68-70 Cancer irroratus.

Fig. 68. Lateral view, zoea 2.
Fig. 69. Antennule, zoea 2.
Fig. 70. Antenna, zoea 2.

(After Sastry 1977b).

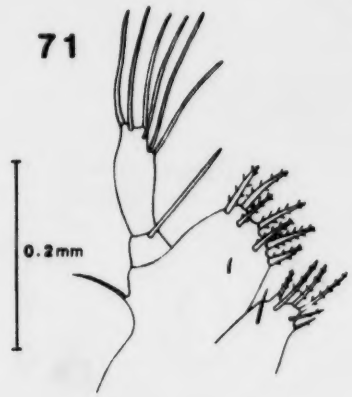


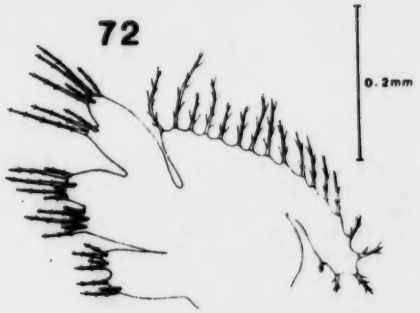
Zoea 3. Maxillule basal and coxal endites with 8 and 7 setae, respectively (Fig. 71); scaphognathite of maxilla with 15–22 plumose setae, generally 18 (Fig. 72).

Fig. 71–72 Cancer irroratus.

Fig. 71. Maxillule, zoea 3.
Fig. 72. Maxilla, zoea 3.

(After Sastry 1977b).

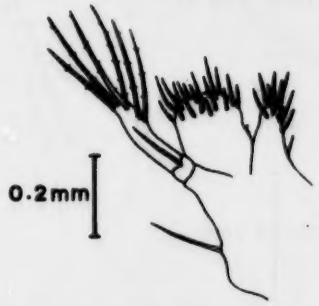




Zoea 4. Maxillule basal and coxal endites with 10+1 and 7 apical setae, respectively (Fig. 73).

Fig. 73. Cancer irroratus, maxillule, zoea 4.

(After Sastry 1977b).

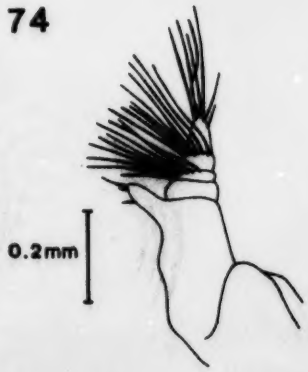


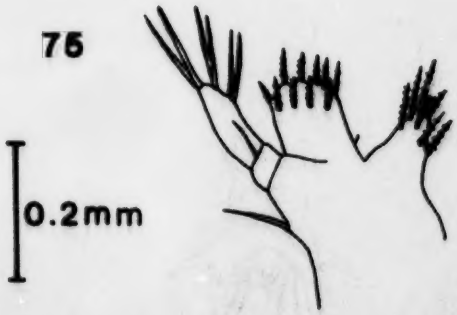
Zoea 5. Antennule segmented, with 3 tiers of aesthetascs, proximal to distal arrangement being: 9, 9, 7 (Fig. 74); maxillule basal and coxal endites with 18 and 10 setae, respectively (Fig. 75).

Fig. 74–75 Cancer irroratus.

Fig. 74. Antennule, zoea 5.
Fig. 75. Maxillule, zoea 5.

(After Sastry 1977b).





27a. Postero-lateral spines on abdomen well developed (Fig. 78, 82), 1 strong lateral spine and 1 smaller inner lateral spine, plus 1 dorsal spine on telson furcae (Fig. 78) 28

27b. Postero-lateral spines on abdomen not well developed, or present as lateral knobs or hooks (Fig. 83, 86); 1 lateral spine (not large) and 1 minute inner lateral spine on telson furcae, dorsal spine of furca present or absent (Fig. 83) 29

28a. Zoea 1, carapace about 1 mm long, only 3 abdominal segments plus telson furcae visible laterally (Fig. 76); exopodites of maxillipeds with 4 setae; zoeas 2, 3, 4 with unusual setal increments as follows:

Zoea stage	No. of setae on exopodite of maxilliped 1	No. of setae on exopodite of maxilliped 2
2	10-11	11
3	~14	~14
4	17	19

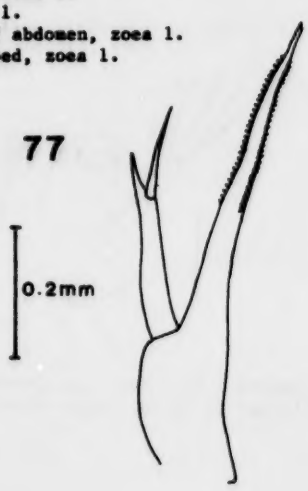
. . . . . Geryon quinquedens Smith, 1878

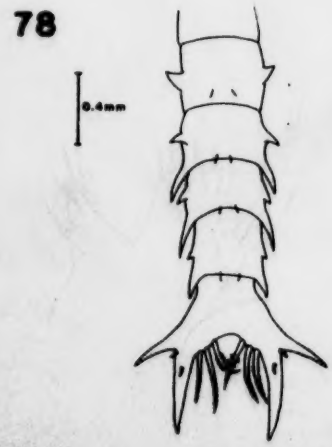
Four zoeal stages. Length from tip of rostral spine to tip of dorsal spine: 1st zoea, 2.78 mm; 2nd, 3.17 mm; 3rd, 4.11 mm; 4th, 5.17 mm. Development time from hatching to first crab at 18-21°C is 39 d. Distribution - Off Nova Scotia to Brazil.

Fig. 76-79 Geryon quinquedens.

Fig. 76. Lateral view, zoea 1.
Fig. 77. Antenna, zoea 1.
Fig. 78. Dorsal view of abdomen, zoea 1.
Fig. 79. First maxilliped, zoea 1.

(After Perkins 1973).





28b. Zoea 1 smaller, carapace about 0.7 mm long, 5 abdominal segments plus telson furcae, visible laterally (Fig. 80), expodites of maxillipeds with 4 setae; zoeas 2, 3, 4, 5 with usual setation increments of 2 as follows:

Zoea stage	No. of setae on expodites of maxilliped 1	No. of setae on expodites of maxilliped 2
2	6	6
3	8	8
4	10	10
5	12	12

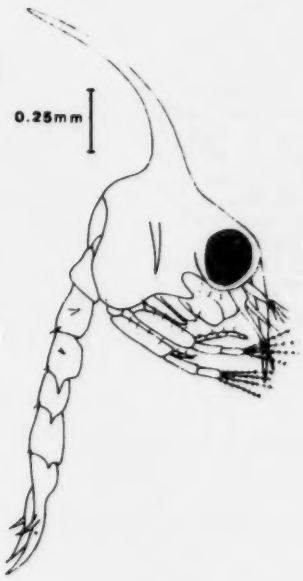
. . . . . Bathynectes superba Costa, 1853

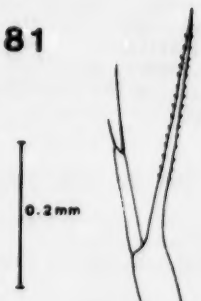
Five zoeal stages. Length from tip of rostral spine to tip of dorsal spine: 1st zoea, 1.62-1.80 mm; 2nd, 1.82-2.06 mm; 3rd, 2.25-2.61 mm; 4th, 3.03-3.44 mm; 5th, 3.58-3.99 mm. Development time from hatch to zoea 5 at 10°C took 32 d.

Fig. 80-82 Bathynectes superba.

Fig. 80. Lateral view, zoea 1.
Fig. 81. Antenna, zoea 1.
Fig. 82. Lateral view, zoea 4.

(After Roberts 1969).





29a. Antennal exopodite about 1/2 length of protopodite and ending in 2 sub-equal setae (Fig. 84); no dorsal spine present on telson furcae, lateral spine and minute inner lateral spine present (Fig. 85); setation on exopodites of maxillipeds as follows:

Zoea stage	No. of setae on exopodites of maxilliped 1	No. of setae on exopodites of maxilliped 2
1	4	4
2	7	7
3	8	10
4	10	12
5	14	15

. . . . . Ovalipes ocellatus (Herbst, 1799)

Length from tip of rostral spine to tip of dorsal spine of zoea 1 to 5 ranges from 1.52-2.43 mm. Development time at 25 o/oo and 20°C was 26.6 d and at 25°C, 17.4 d. Melanophores are distributed in the following patterns: 1) a pair, median and slightly dorsal to eyes; 2) a pair, anterior and slightly lateral to the base of the dorsal carapace spine; 3) posterior to eyes; 4) dorsal to heart; 5) lateral surface of cephalothorax dorsal to lateral spine; 6) lateral surface of cephalothorax, ventral to lateral spine; 7) mandibles and labrum; 8) first abdominal segment, median and dorsal to gut; 9) abdominal segments 2-5, postero-ventral surface; 10) basipodites of maxillipeds 1 and 2. The sixth abdominal somite, added in the 3rd zoeal stage, also a pair of melanophores on the postero-lateral surface. Distribution - Prince Edward Island; Minas Basin, Nova Scotia, from Provincetown, Cape Cod, Massachusetts, to South Carolina and Texas coast jetties.

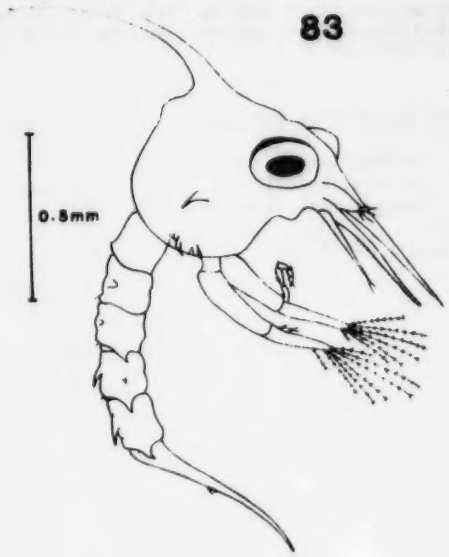
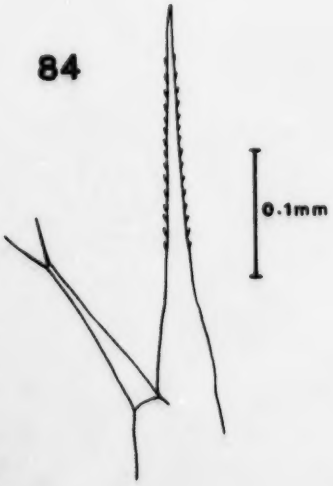
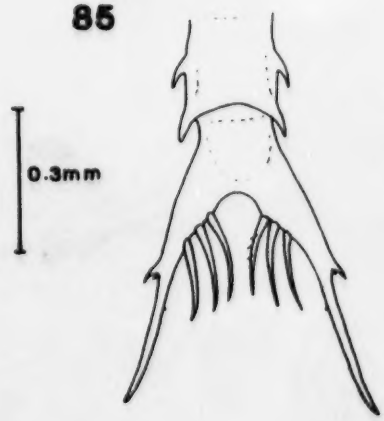


Fig. 83-85 Ovalipes ocellatus.

Fig. 83. Lateral view, zoea 2.
Fig. 84. Antenna, zoea 2.
Fig. 85. Abdomen, dorsal view, zoea 2.

(After Costlow and Bookhout 1966c).





29b. Antennal exopodite much less than 1/2 length of protopodite and ending in 2 sub-equal setae (Fig. 87); dorsal spine present on telson furcae plus lateral spine and small inner lateral spine (Fig. 88) . . . . . Portunus sayi (Gibbes, 1850)

(N.B. this species is not well known, only zoea 1 has been described (see Appendix 10). Portunus appears to be a variable genus, Portunus spinicarpus and P. gibbesii are described. The maxilliped setation of Portunus spinicarpus is as follows:

Zoea stage	No. of setae on exopodites of maxilliped 1	No. of setae on exopodites of maxilliped 2
1	4	4
2	6	6
3	8	8
4	10	10
5	10	11
6	13	14
7	14	15

The body of the 1st zoea has a faint purplish-pink tinge and there are black chromatophores in the mouth region, in the thorax and abdomen and on the maxillipeds. Distribution - North Atlantic Ocean from Nova Scotia south through Gulf of Mexico to Brazil; mid-Atlantic Ocean, Bermuda; Kerguelen Island, south Indian Ocean

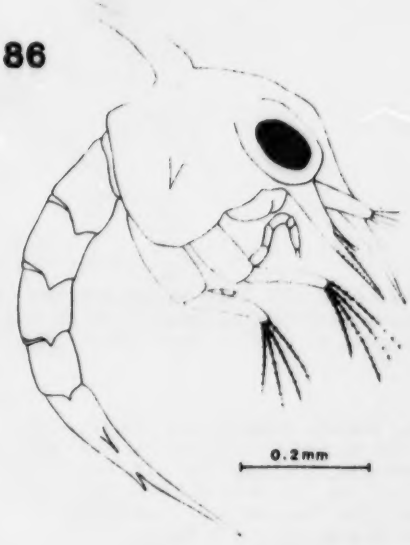
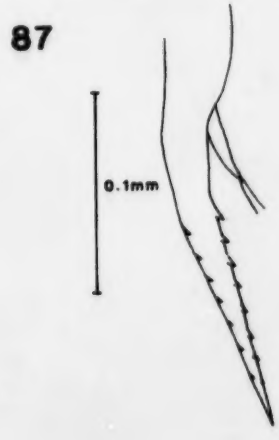
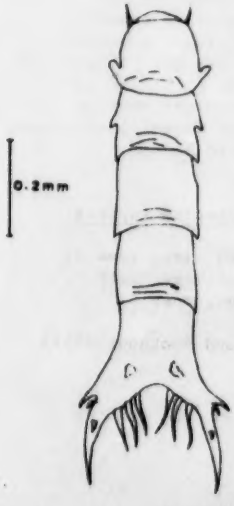


Fig. 86-88 Portunus sayi.

Fig. 86. Lateral view, zoea 1.
Fig. 87. Antenna, zoea 1.
Fig. 88. Abdomen, dorsal view, zoea 1.

(After Lebour 1944).





30a. Telson furcae with 1 dorsal and 2 lateral (one minute inner) spines (Fig. 91); postero-lateral spines on abdominal somites 3-5 short and bifid; lateral spine to rostral spine length ratio about 1.3 (Fig. 89). . . . . Arenaeus cribrarius (Lamarck, 1818)

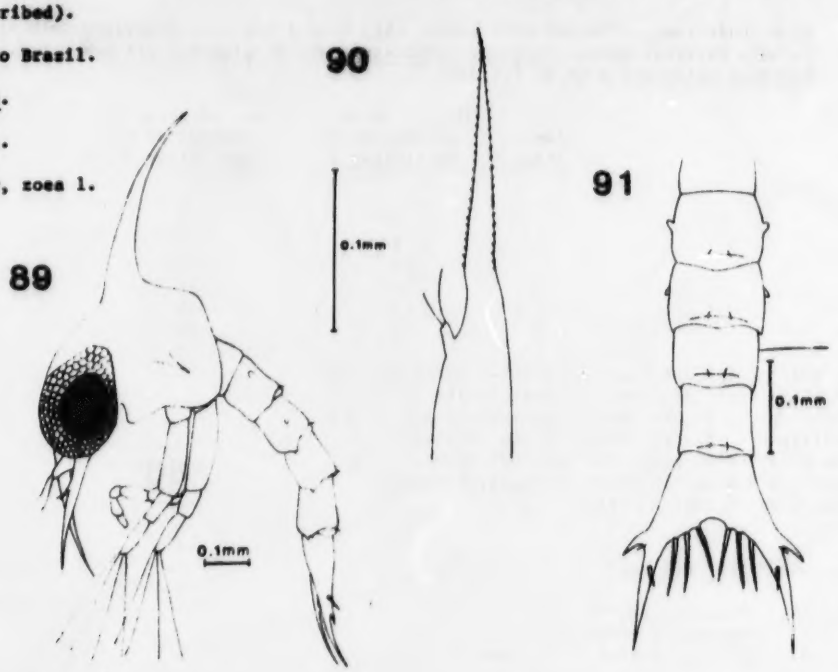
(N.B. Only zoea 1 is described).

Distribution - Massachusetts to Brazil.

Fig. 89-91 Arenaeus cribrarius.

Fig. 89. Lateral view, zoea 1.
Fig. 90. Antenna, zoea 1.
Fig. 91. Abdomen, dorsal view, zoea 1.

(After Sandifer 1972).



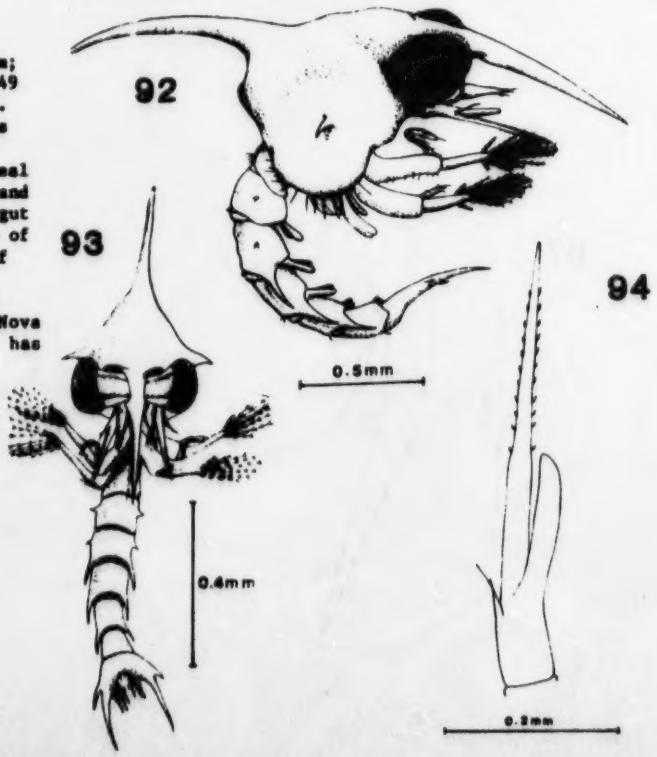
30b. Telson furcae with 1 dorsal and 1 lateral spine (perhaps 1 minute lateral spine also); postero-lateral spines on abdominal somites 3-5 relatively long and sharply pointed, those on somites 3 and 4 overlapping most of the next somite (Fig. 92, 94); lateral spine to rostral spine length ratio about 1:5 (Fig. 92) . . . . . Callinectes sapidus Rathbun, 1896

Eight zoeal stages. Length from tip of rostral spine to tip of dorsal spine of 1st zoea, 0.83 mm; 2nd, 1.0 mm; 3rd, 1.13 mm; 4th, 1.22 mm; 5th, 1.49 mm; 6th, 1.69 mm; 7th, 2.06 mm; and 8th, 2.29 mm. Development time from hatching to megalopa varies from 37 to 53 d at 26.7 o/oo and 25°C. The chromatophore patterns are consistent for all zoeal stages: between the eyes; posterior to the eye and dorsolateral to anterior part of gut; dorsal to gut in posterior region of cephalothorax, below base of dorsal carapace spine; mandible; distal region of basipodite of first maxilliped; middle of first abdominal somite, dorsal to gut; margin of third through last abdominal somites. Distribution - Nova Scotia (no longer endemic) to Uruguay; Bermudas; has been introduced to Europe.

Fig. 92-94 Callinectes sapidus.

Fig. 92. Frontal view, zoea 3.
Fig. 93. Lateral view, zoea 7.
Fig. 94. Antenna, zoea 7.

(After Costlow and Bookhout 1959).



ARTIFICIAL KEY TO MEGALOPAS OF THE BAY OF FUNDY AND SCOTIAN SHELF REGION

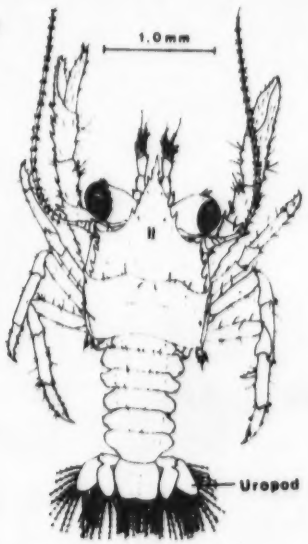
1a. Uropods present (Fig. 95, 96) . . . . . Anomura (most), Macrura

Within the Anomura, the two species most frequently encountered as megalopas off the Scotian Shelf are Galathea rostrata and Dromidia antillensis. Although these are not Brachyura, a brief description of each is given in Appendix 3, since they may be easily confused with Brachyuran megalopas.

Fig. 95. Galathea rostrata, megalopa, dorsal view.
Fig. 96. Dromidia antillensis megalopa, dorsal view.

(Fig. 95 after Gore 1979)
(Fig. 96 after Rice and Provenzano 1966)

95



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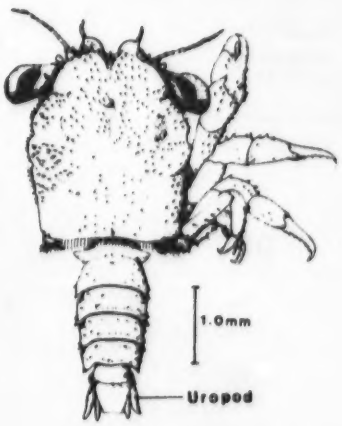


1b. Uropods absent (Fig. 97, 98) . . . . . Brachyura, Anomura (Lithodidae) 2

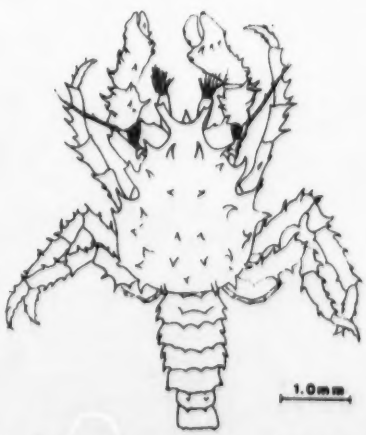
2a. Body and legs extremely spiny; pereiopods 5 reduced (Fig. 97) . . . . . Anomura Lithodidae, only one local species . . . . . Lithodes maja (Linnaeus, 1758)

(N.B. Neolithodes grimaldii also occurs off Scotian Shelf - larvae are not described.)

Fig. 97. Lithodes maja, dorsal view, megalopa.

(After Pike and Williamson 1959).

97



2b. Body and legs sparsely spined or without spines, although setae may be present; pereiopods 5 not reduced (Fig. 98) . . . . . Brachyura 3

3a. Carapace with dorsal spines (Fig. 98, 101, 110) 4

3b. Carapace without dorsal spines; rostral spine(s) only may be present; dorsal surface of carapace may have bumps (Fig. 120, 124, 128, 129) 11

4a. Carapace with more than one dorsal spine (Fig. 98, 101) 5

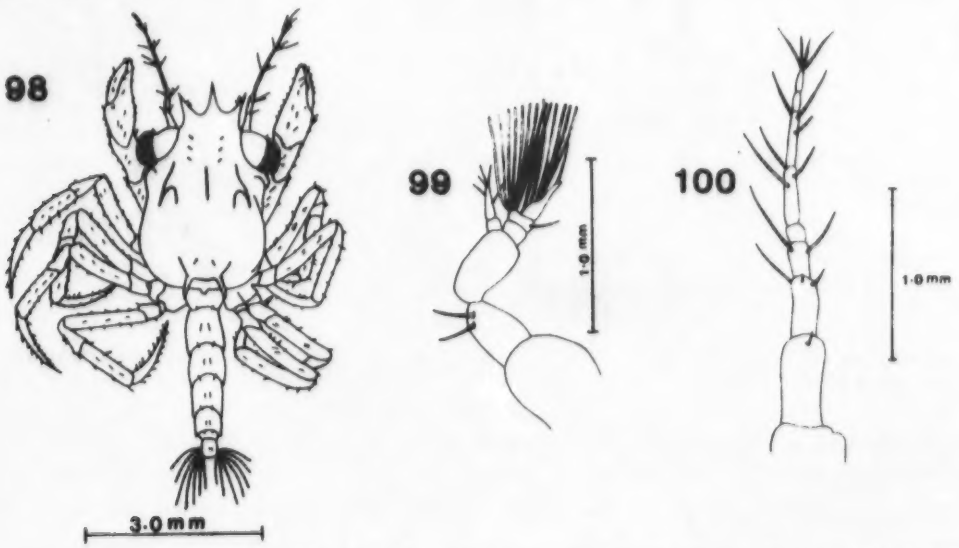
4b. Carapace with one posterior dorsal spine (Fig. 108, 111, 116, 118) 8

5a. One pair postero-dorsal, and one pair mid-dorsal spines present (Fig. 98) . . . . . Chionoecetes opilio (O. Fabricius, 1780) (Fig. 98-100).

Fig. 98-100 Chionoecetes opilio megalopa.

Fig. 98. Dorsal view.
Fig. 99. Antennule.
Fig. 100. Antenna.

(Fig. 98 after Kurata 1963).
(Fig. 99, 100 after Motoh 1973).



5b. Single postero-dorsal, and one pair mid- or anter-dorsal spines present (Fig. 101, 102, 104, 106) 6

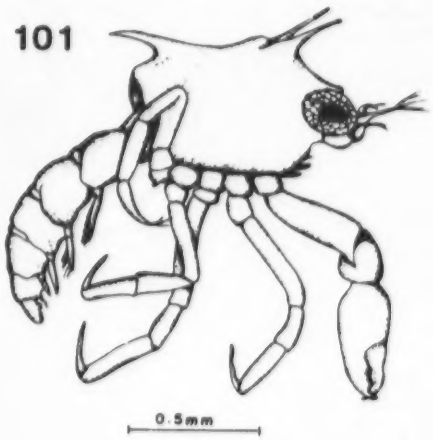
6a. No lateral rostral spines, rostrum blunt and rounded; one pair dorsal forward pointing spines present (Fig. 101, 102) . . . . . Pinnotheres maculatus Say, 1818

Carapace length - 0.77 mm. Chromatophore pattern: 1) a pair, median to eyestalks; 2) dorsal surface of eyestalks; 3) immediately posterior to eyestalks; 4) postero-lateral surface of carapace; 5) dorsal spine; 6) first abdominal somite, dorsal to gut, and extending anteriorly into thorax and posteriorly into second abdominal somite; 7) postero-lateral borders of abdominal somites 2-6.

Fig. 101-103 Pinnotheres maculatus megalopa.

Fig. 101. Dorsal view.
Fig. 102. Lateral view.
Fig. 103. Antennule and antenna.

(After Costlow and Bookhout 1966b).



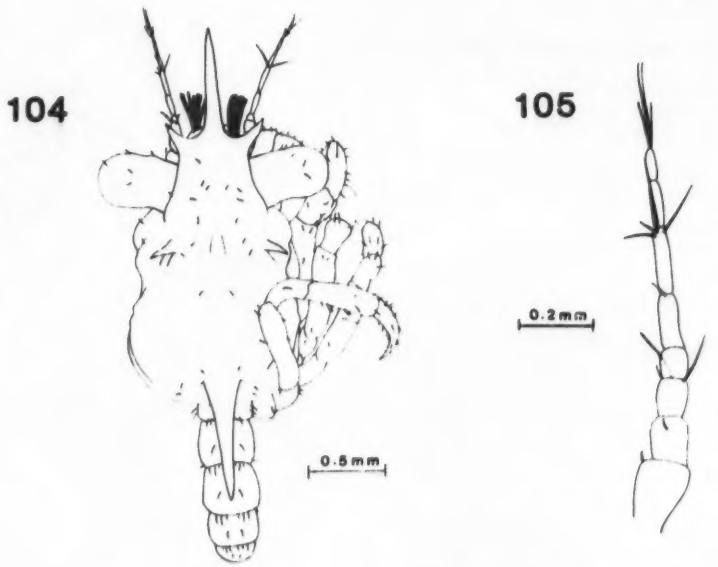
6b. Long lateral rostral spines present; one pair dorsal spines, pointing posteriorly (Fig. 104, 106) . . . 7

7a. Length from tip of rostrum to tip of dorsal spine, average 3.40 mm, range 3.30-3.63; carapace width, average 1.51 mm, range 1.48-1.65 mm; median rostral spine extends beyond the third (distal) segment of the antennal flagellum, and may be as long as the antenna in some specimens; dorsal spine in dorsal view, reaching backwards to abdominal somite 3 (Fig. 104) . . . . . Hyas araneus (Linnaeus, 1758)

Fig. 104-105 Hyas araneus megalopa.

Fig. 104. Dorsal view.
Fig. 105. Antenna.

(After Christiansen 1973).

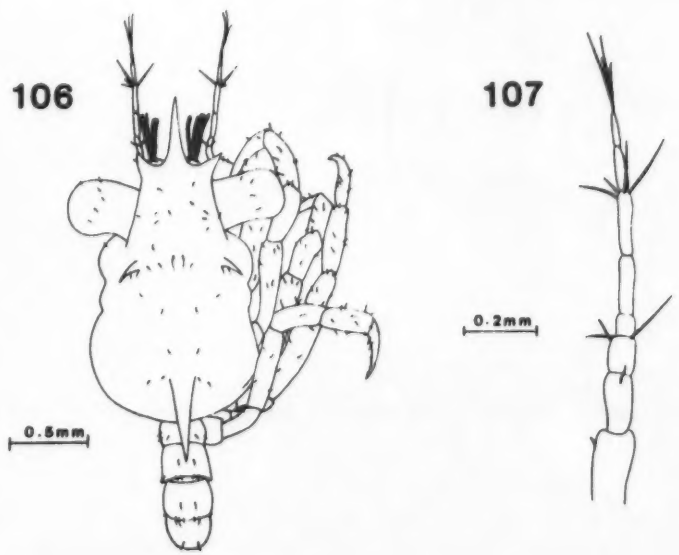


7b. Length from tip of rostrum to tip of dorsal spine, average 2.30 mm, range 2.19-2.47 mm; carapace width, average 1.16 mm, range 1.07-1.24 mm; median rostral spine does not reach beyond the third (distal) of antennal flagellum, or at most only reaches slightly beyond this segment; dorsal spine in dorsal view reaching only to abdominal somite 2 (Fig. 106) . . . . . Hyas coarctatus Leach, 1815

Fig. 106-107 Hyas coarctatus megalopa.

Fig. 106. Dorsal view.
Fig. 107. Antenna.

(After Christiansen 1973).



8a. Prominent rostrum nearly as long as carapace; very long chelipeds reaching to end of rostrum (Fig. 108, 109) . . . . . Parthenope sp.

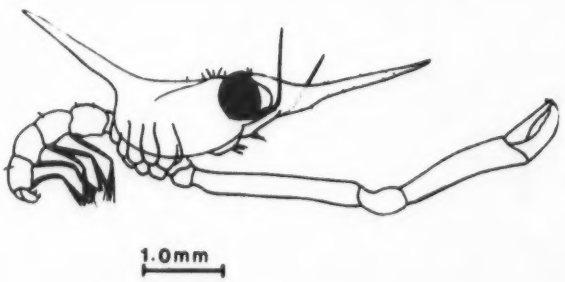
(Probably the undescribed megalopa of P. pourtalesii (Stimpson, 1817))

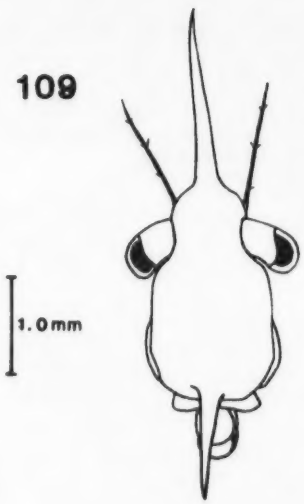
Ovigerous female observed in December off coast of North Carolina. Distribution - Off Martha's Vineyard, Mass., latitude of New Jersey through West Indies to Grenada.

Fig. 108-109 Parthenope pourtalesii megalopa.

Fig. 108. Lateral view.
Fig. 109. Dorsal view.

(After Lebour 1944).





8b. Rostrum not more than 1/4 length of carapace; chelipeds not elongate (Fig. 109, 110, 115, 118) 9

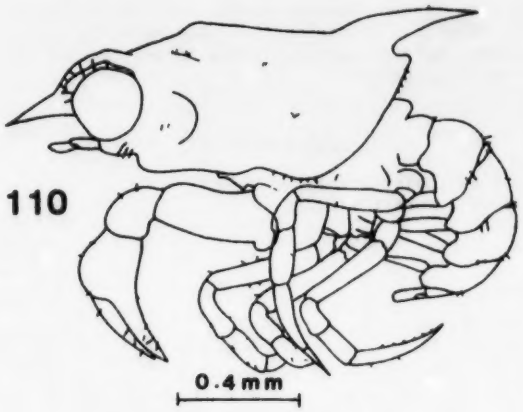
9a. Carapace produced into small lateral spines posteriorly; carapace in dorsal view rather triangular (Fig. 111) . . . . . Parthenope serrata (Milne-Edwards, 1834)

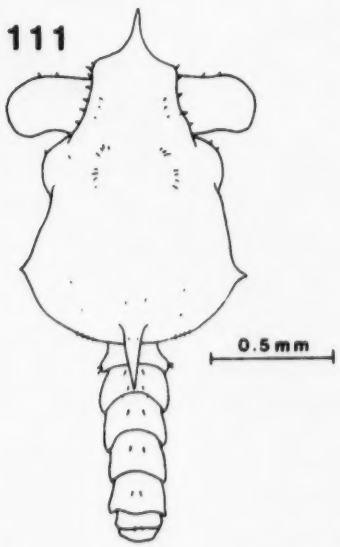
Ovigerous females observed in June off coast of North Carolina. Distribution - Adults - off the three North Carolina capes; Gulf of Mexico from Pensacola to southern Florida, and off Campecne, Mexico; West Indies to Bahia, Brazil.

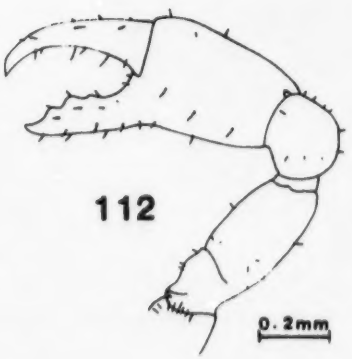
Fig. 110-115 Parthenope serrata megalopa.

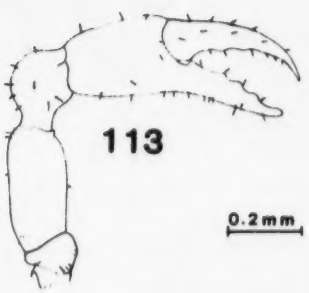
Fig. 110. Lateral view.
Fig. 111. Dorsal view.
Fig. 112. Right cheliped.
Fig. 113. Left cheliped.
Fig. 114. Antennule.
Fig. 115. Antenna.

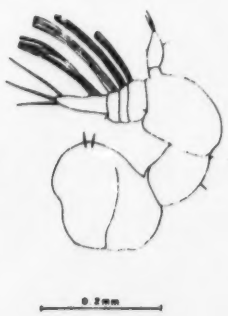
(After Yang 1971).

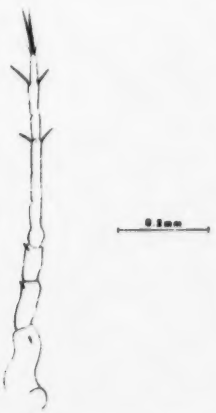












9b. Carapace not produced into lateral spines; carapace in dorsal view rather square (Fig. 116, 118) . . . . . Cancer 10

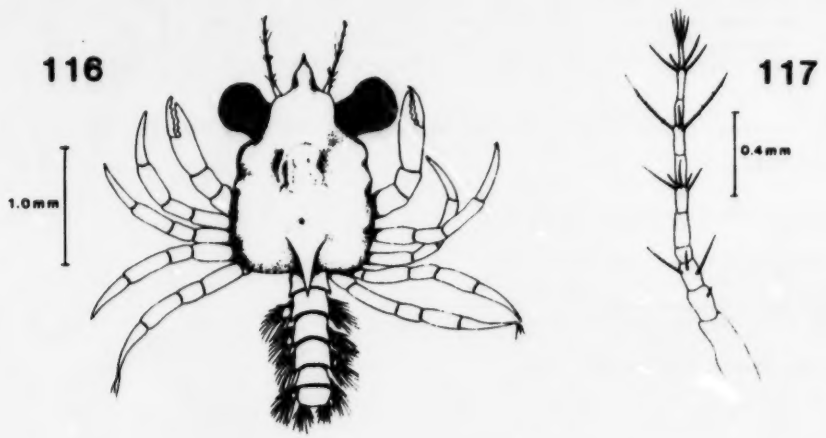
10a. Rostrum produced into a fine point; setae of fourth antennal segment (counting from distal end) do not reach end of antenna; no setae on third antennal segment (Fig. 116, 117) . . . . . Cancer borealis Stimpson, 1859

Carapace length - 2.0-3.0(+) mm.

Fig. 116-117 Cancer borealis megalopa.

Fig. 116. Dorsal view.
Fig. 117. Antenna.

(After Sastry 1977a).



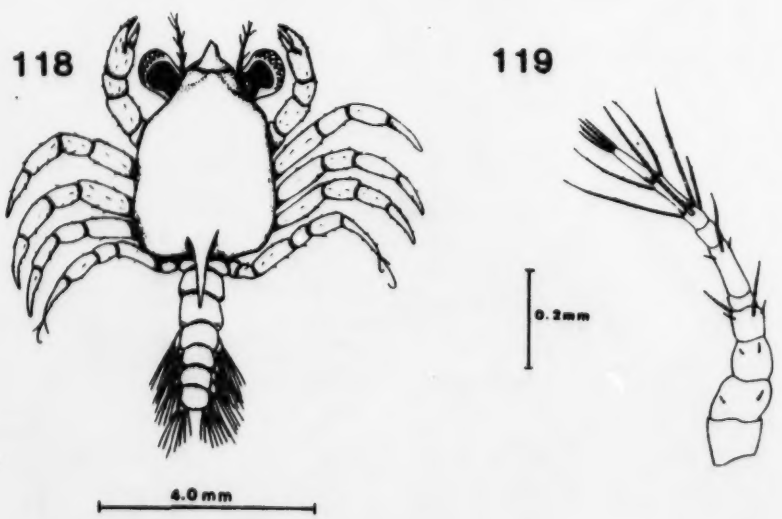
10b. Rostrum shorter and more rounded; no setae on fourth antennal segment; setae of third antennal segment (counting from distal end) reach beyond end of antenna (Fig. 118, 119) . . Cancer irroratus Say, 1817

Carapace length - 3.3-4.0 mm.

Fig. 118-119 Cancer irroratus megalopa.

Fig. 118. Dorsal view.
Fig. 119. Antenna.

(After Sastry 1977b).



11a. Rostrum not produced into a spine, lateral rostral spines absent, rostrum may be anteriorly depressed but not bifid at tip (Fig. 120, 124, 128, 129) 12

11b. Rostral spine or spines present, although they may be very short or present as knobs, rostrum may be anteriorly depressed and bifid at tip (Fig. 135, 136, 139, 141) 17

12a. Smaller megalopas (0.5-1.5 mm in carapace length); posterior margin of carapace rounded and dorsal surface of carapace smooth; rostrum flat, may have small medial indentation; antennae very small consisting of 5 or 6 segments with few setae (Fig. 120-124) 13

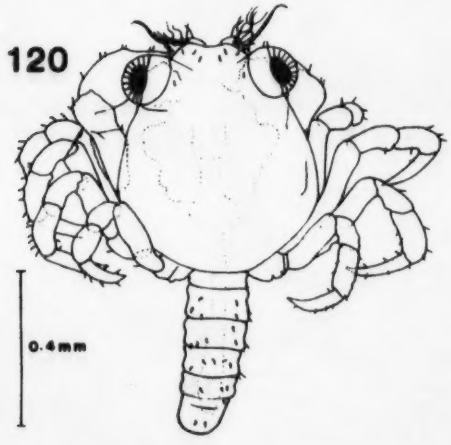
12b. Mostly larger megalopas (usually greater than 2.0 mm in carapace length); posterior margin of carapace rounded or squared, but if carapace length is less than 2.0 mm then posterior margin of carapace is squared, dorsal surface of carapace smooth or bumpy; rostrum flat, may be medially notched or depressed ventrally; antennae of more than 6 segments bearing numerous setae (Fig. 128-133) 14

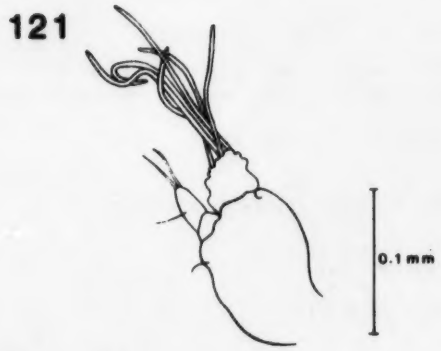
13a. Antenna of 6 segments; terminal segment with one long and one short seta (Fig. 121) . . . . . Pinnotheres ostreum Say, 1817

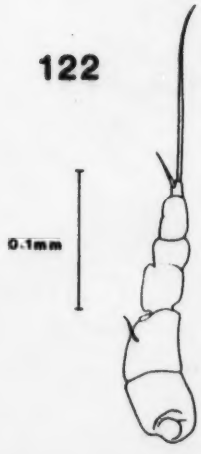
Fig. 120-123 Pinnotheres ostreum.

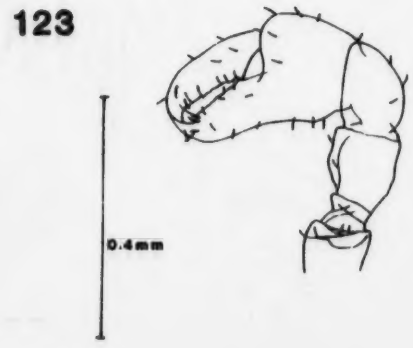
Fig. 120. Dorsal view, megalopa.
Fig. 121. Antennule, megalopa.
Fig. 122. Antenna, crab 1.
Fig. 123. Right cheliped, dorsal view, megalopa.

(After Sandoz and Hopkins 1947).









13b. Antenna of 5 rather rounded segments, only the terminal segment bears one very long seta (Fig. 125) . . . . . Pinnotheres chamae Roberts, 1975

OR terminal segment bears three long and two shorter lateral setae (Fig. 127) . . . . . Pinnotheres spp. (larvae undescribed)

N.B. Other arrangements of antennal setation may be possible in the family Pinnotheridae . . . . . (see Appendix 5)

Three zoeal instars and one megalopa. Carapace of megalopa is 0.48 mm. Megalopa has scattered brown-black chromatophores. Distribution - North Carolina to Nova Scotia.

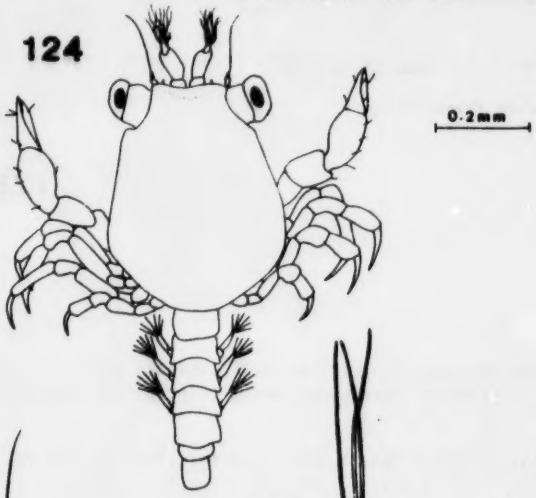
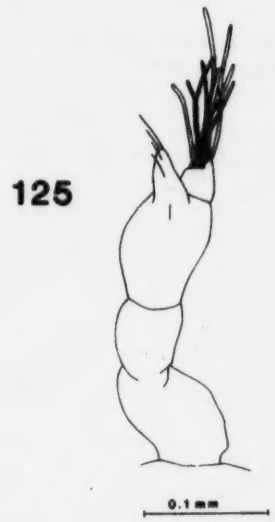
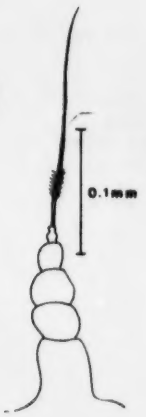


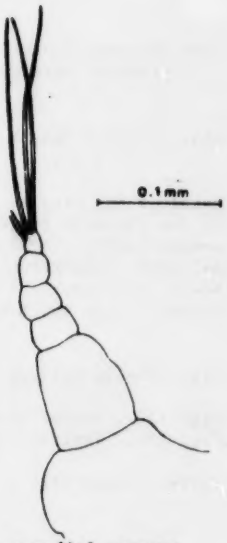
Fig. 124-126 Pinnotheres chamae megalopa.

Fig. 124. Dorsal view.
Fig. 125. Antennule.
Fig. 126. Antenna.
Fig. 127. Pinnotheridae, antenna megalopa.

(Fig. 124-126 after Roberts 1975b).





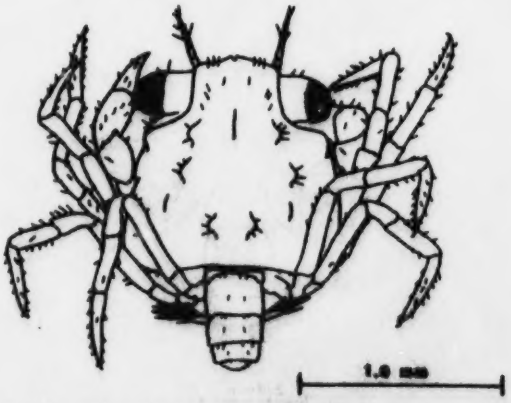


14a. Smaller megalopas (carapace length about 1.1 mm); rostrum deflected ventrally with a medial groove; carapace hairy with dorsal bumps and somewhat squared posterior margin (Fig. 128) . . . . . Rhithropanopeus harrisii (Gould, 1841)

(N.B. Although this species has been described, the published descriptions are still inadequate).

Fig. 128. Rhithropanopeus harrisii, Dorsal view, megalopa.

(After Connolly 1925).



14b. Larger megalopas (carapace length greater than 2.0 mm); carapace smooth with sparse setation (Fig. 129, 130, 132) 15

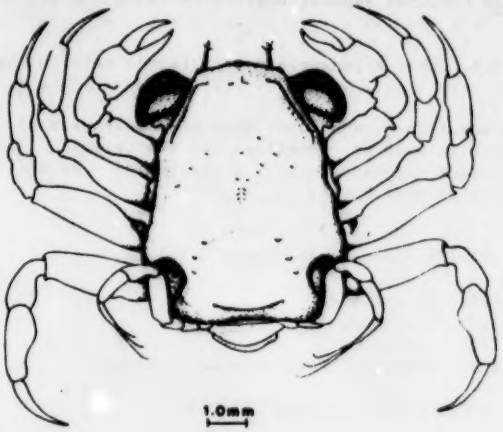
15a. Large crab-like megalopas (carapace length over 5.5 mm); carapace nearly as wide as long, large lateral knobs present ventrally just posterior to eyes; abdomen recurved under body; manus of cheliped not greatly expanded, pincers stout (Fig. 129) . . . . . Ocypode quadrata (Fabricius, 1787)

Distribution - Adults - Block Island, Rhode Island, to State of Santa Cantarina, Brazil; megalopa - Nova Scotia; Vineyard Sound, Massachusetts and Narragansett Bay, Rhode Island.

Fig. 129. Ocypode quadrata, dorsal view, megalopa.

(After Crane 1940)

129



15b. Carapace longer than wide; abdomen extended posteriorly; manus of cheliped greatly expanded with fine pincers; pereiopods small in proportion to cheliped and carapace size (Fig. 130, 132) 16

16a. Carapace length about 5.1 mm; (species not yet fully described, see Appendix 9) . . . . . Calappa flammea (Herbst, 1794)

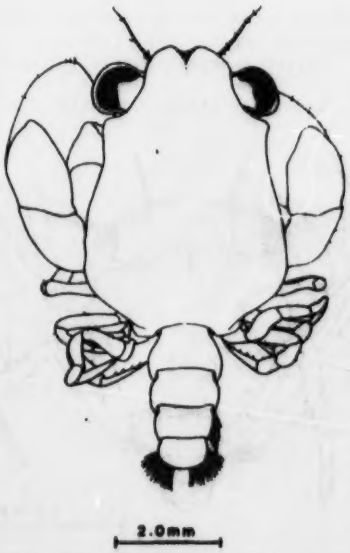
Megalopa has very large oil-like spherical globules in the thoracic region, always 12 in number and symmetrically placed. The body is a pale yellowish all over. Distribution - Adults - Cape Hatteras, North Carolina, to Florida Keys; Gulf coast of United States and Mexico; Bahamas; Bermuda.

Fig. 130-131 Calappa flammea.

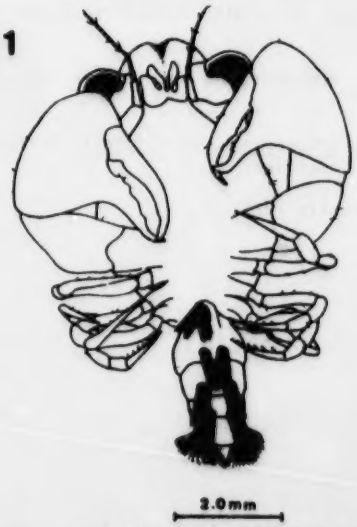
Fig. 130. Dorsal view.
Fig. 131. Ventral view.

(After Lebour 1944).

130



131



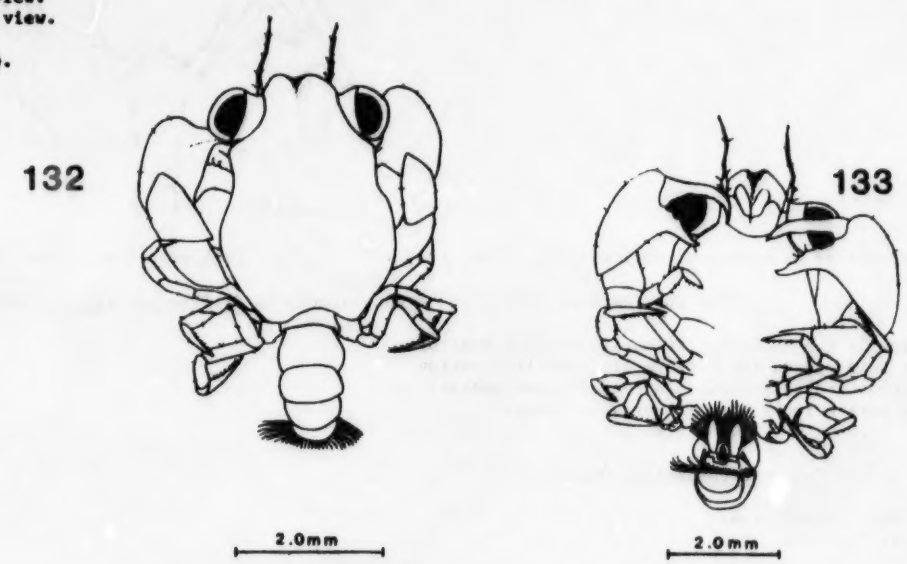
16b. Carapace length about 2.9 mm; (species not yet fully described, see Appendix 9) . . . . . tentatively Cyclo̲ḛ̲s̲ bairdii Stimpson, 1860 (possibly Calappa marmorata), see Appendix 9.

The megalopa is pale yellow with small red spots.
There are 14 large globules in the thorax.
Distribution - Adult - North Carolina to Caribbean Sea; Bermuda; west coast of Mexico to Ecuador and the Galapagos Islands: larvae - to Nova Scotia.

Fig. 132-133 Cyclo̲ḛ̲s̲ bairdii megalopa.

Fig. 132. Dorsal view.
Fig. 133. Ventral view.

(After Lebour 1944).



17a. No lateral rostral spines present; rostral spine long pointing anteriorly; last thoracic segments of sternum with two posteriorly pointing ventral spines (Fig. 134) . . (family Portunidae, see Appendix 10) 18

Fig. 134. Callinectes sapidus Rathbun, 1896.
Abdomen, ventral view, megalopa.

(After Costlow and Bookhout 1959).

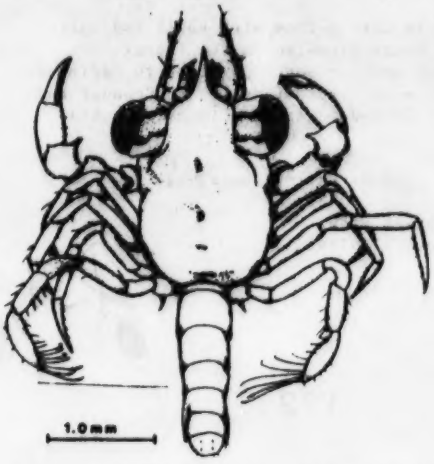
17b. Lateral rostral spines present or absent; rostral spine pointing anteriorly or depressed ventrally; last thoracic segment of sternum without distinct spines (although hairs or setae may be present) (Fig. 139, 141, 146) 19

18a. Two spines on carpus of chelipad (Fig. 135) . . . . . Portunus spp. (see Appendix 10)

Fig. 135. Portunus spinicarpus. Dorsal view, megalopa.

(After Bookhout and Costlow 1974).

135



18b. No spines on carpus of chelipid (Fig. 136, 137) . . . . . Callinectes spp. (see Appendix 10)

(The species most likely to be encountered is Callinectes sapidus Rathbun, 1896)

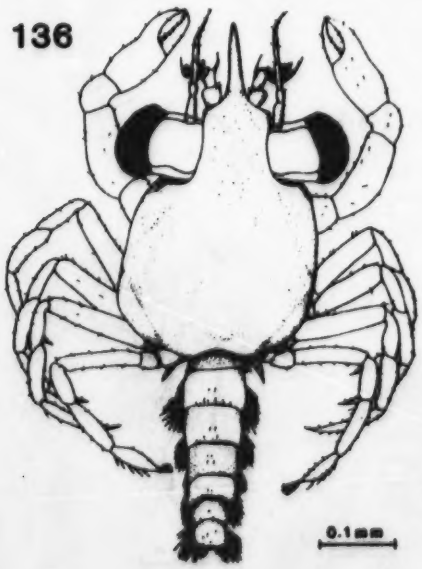
Carapace length 1.71 mm. Primarily benthic megalopa larvae swim upward for a short distance from bottom when subjected to pressure increased above ambient value, particularly when illuminated above.

Fig. 136-137 Callinectes sapidus megalopa.

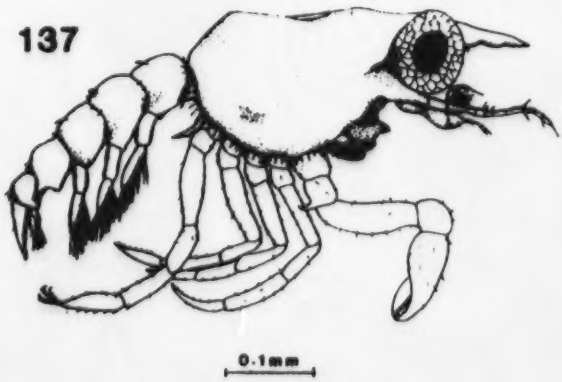
Fig. 136. Dorsal view.
Fig. 137. Lateral view.

(After Costlow and Bookhout 1959).

136



137



19a. Rostrum with lateral spines or knobs (Fig. 139, 141, 146) 20

19b. Rostrum without lateral spines or knobs (Fig. 150, 153, 155) 22

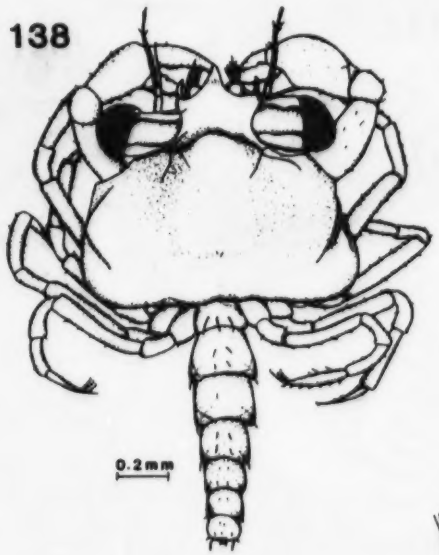
20a. Lateral rostral spines strongly developed; rostrum slightly depressed but still pointing anteriorly; carapace with dorsal elevation behind rostrum (Fig. 138-140) . . Panopeus herbstii Milne-Edwards, 1834

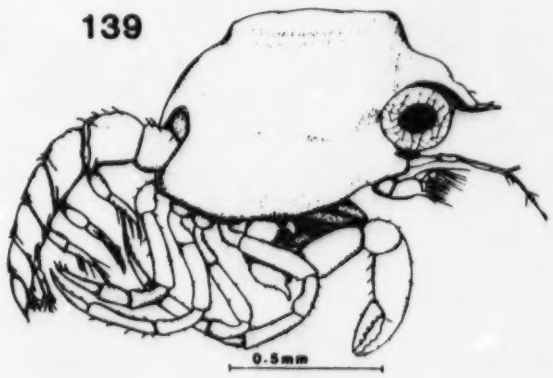
Carapace length - ~1.00 mm.

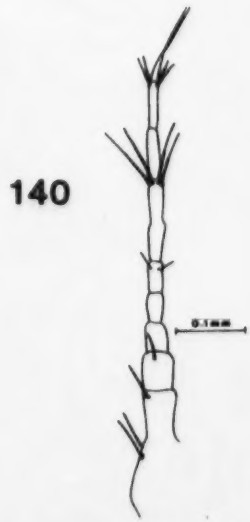
Fig. 138-140 Panopeus herbstii megalopa.

Fig. 138. Dorsal view.
Fig. 139. Lateral view.
Fig. 140. Antenna.

(After Costlow and Bookhout 1961a).







20b. Only lateral rostral knobs present; rostrum strongly depressed (Fig. 141, 144, 146) 21

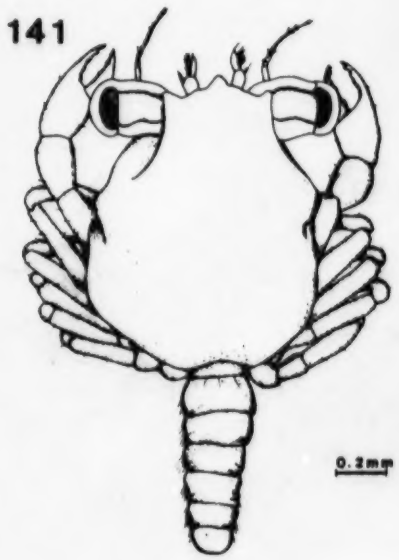
21a. Carapace longer than wide; rostrum apex bluntly rounded; posterior margins of carapace broadly rounded; no aesthetascs on basal segment of segmented antennular flagellum and no setae on third segment of antennule (Fig. 141-144) . . . . . Hepatus epheliticus (Linnaeus, 1763)

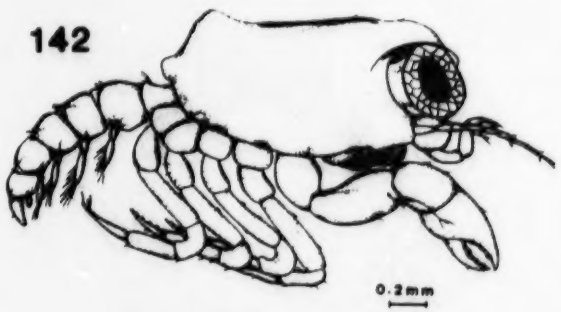
Carapace length - 1.27 mm.

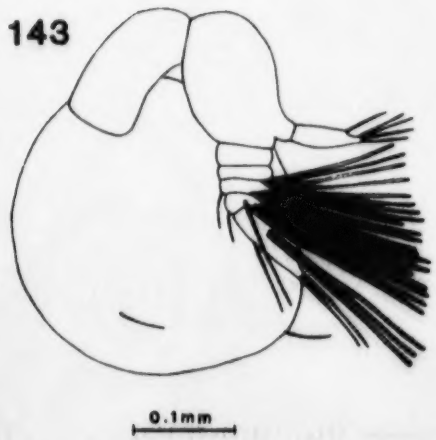
Fig. 141-144 Hepatus epheliticus megalopa.

Fig. 141. Dorsal view.
Fig. 142. Lateral view.
Fig. 143. Antennule.
Fig. 144. Antenna.

(After Costlow and Bookhout 1962a).







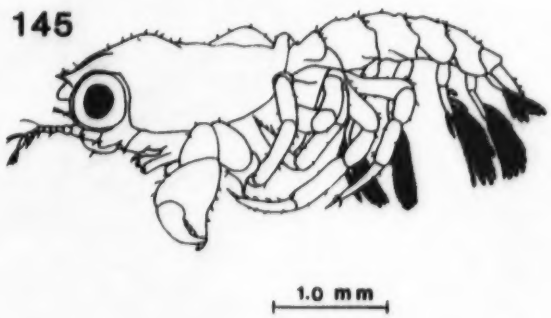
21b. Carapace about as long as wide; rostrum apex notched; posterior margins of carapace straight; a tier of aesthetascs is present on the basal segment of antennule flagellum and setae are present on the third segment of the antennule (Fig. 145-149) . . . . . Neopanope texana spp. (see Appendix 8)

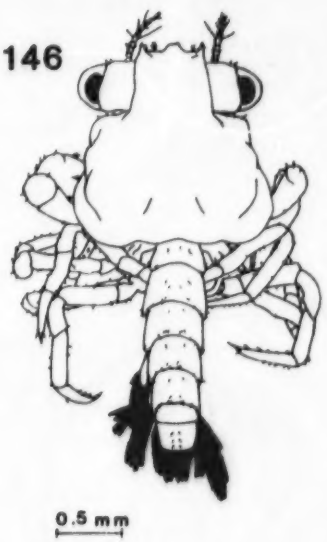
Carapace length - 2.0 mm.

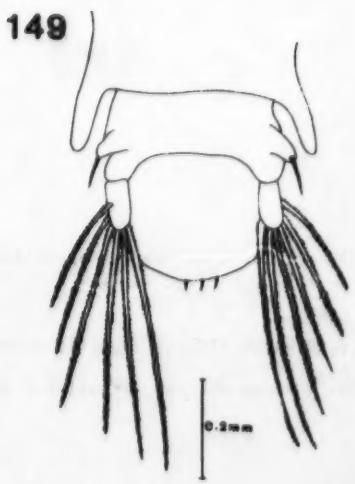
Fig. 145-149 Neopanope texana texana (Smith, 1869).

Fig. 145. Lateral view, megalopa.
Fig. 146. Dorsal view, megalopa.
Fig. 147. Antennule.
Fig. 148. Antenna.
Fig. 149. Telson.

(After McMahan 1967).







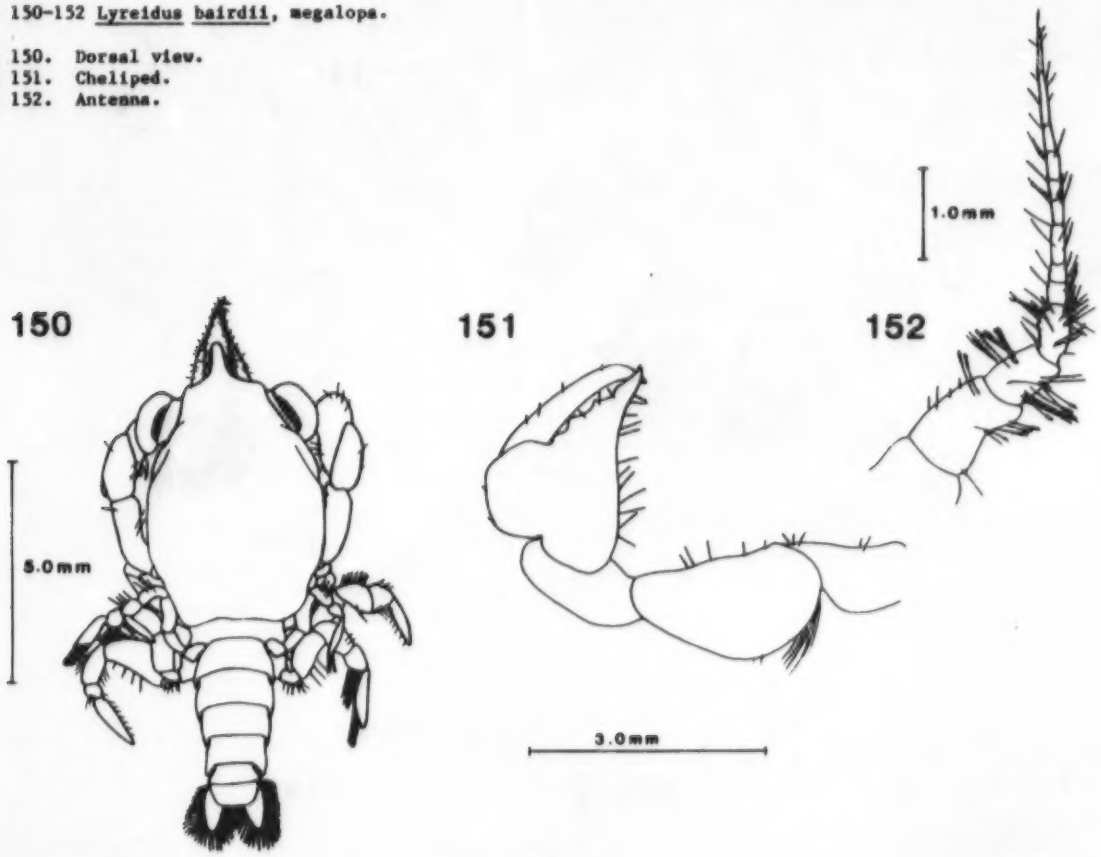
22a. Larger megalops (carapace length about 7.9 mm) with robust elongated body and abdomen; short anteriorly pointing rostral spine, bluntly rounded at tip, ventral septum on rostral spine; antenna of 14 segments heavily setose (Fig. 150-152) . . . . . Lyreidus bairdii Smith, 1881

(Tentative identification, undescribed megalops of the family Raninidae).

Distribution - Adult - off Martha's Vineyard, Massachusetts to Gulf of Mexico and the Greater Antilles; larvae - to Nova Scotia.

Fig. 150-152 Lyreidus bairdii, megalops.

Fig. 150. Dorsal view.
Fig. 151. Cheliped.
Fig. 152. Antenna.



22b. Smaller megalops (carapace length less than 4 mm); antenna of 11 or fewer segments (Fig. 153, 155, 157, 159) 23

23a. Rostrum bluntly rounded; telson rounded (Fig. 153, 155) 24

23b. Rostrum pointed, or pointed and bifid at tip; telson rather square-ended (Fig. 157, 159) . . 25

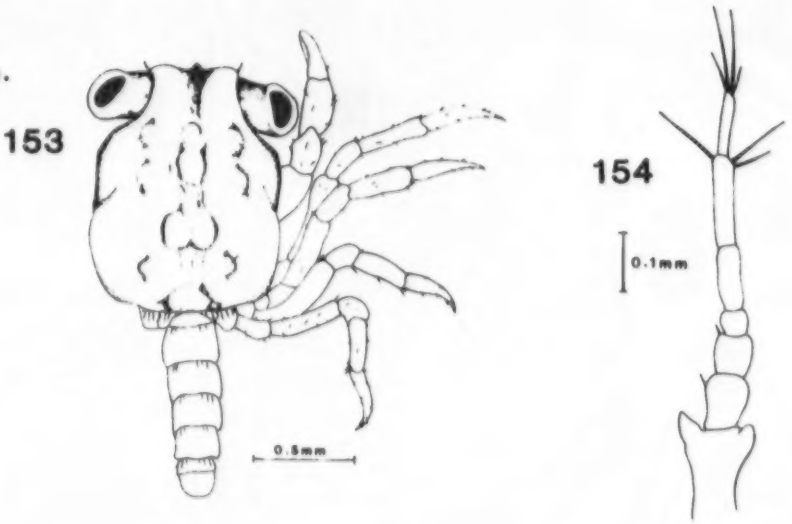
24a. Dorsal surface of carapace with distinct protuberances; 4 terminal setae of antenna of unequal length, 3 setae distally on penultimate segment of antenna (Fig. 153, 154) . . . . Libinia emarginata Leach, 1815

Carapace length - 1.16-1.20 mm.

Fig. 153-154 Libinia emarginata, megalopa.

Fig. 153. Dorsal view.
Fig. 154. Antenna.

(After Johns and Lang 1977).



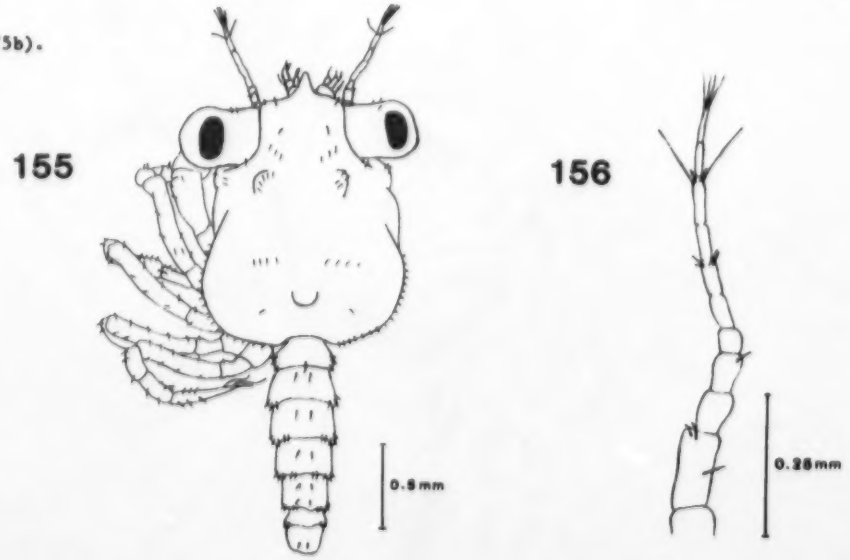
24b. Dorsal surface of carapace without marked protuberances; 4 terminal setae of antenna of equal length, no setae on distal end of penultimate segment; red or black chromatophores may be present over body, chiefly at the bases of eyes and mouthparts, lateral margins of carapace and base of pleopods (Fig. 155, 156) . . . . . Carcinus maenas (Linnaeus, 1758)

Carapace length - 1.45 mm. Megalopa swims upwards with a pressure increment of as little as 0.01 atm.

Fig. 155-156 Carcinus maenas, megalopa.

Fig. 155. Dorsal view.
Fig. 156. Antenna.

(After Rice and Ingle 1975b).



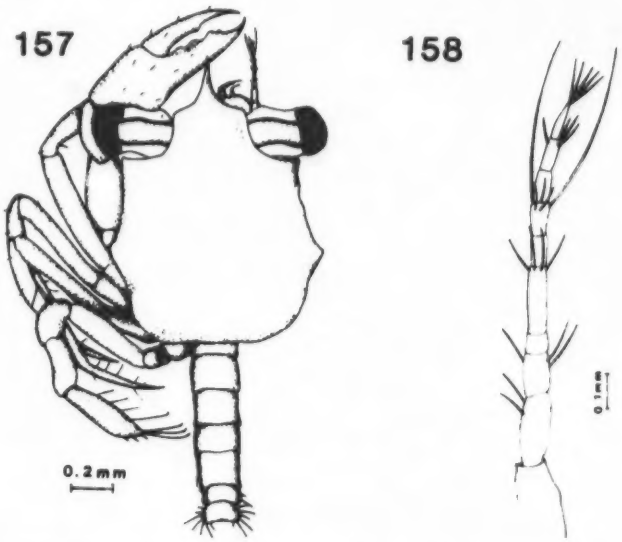
25a. Rostrum produced into a point; very long setae of antennal segment 7 extend beyond end of antenna (Fig. 157, 158) . . . . . Ovalipes ocellatus (Herbst, 1799)

Carapace length - ~1.4 mm.

Fig. 157-158 Ovalipes ocellatus, megalopa.

Fig. 157. Dorsal view.
Fig. 158. Antenna.

(After Costlow and Bookhout 1966c).



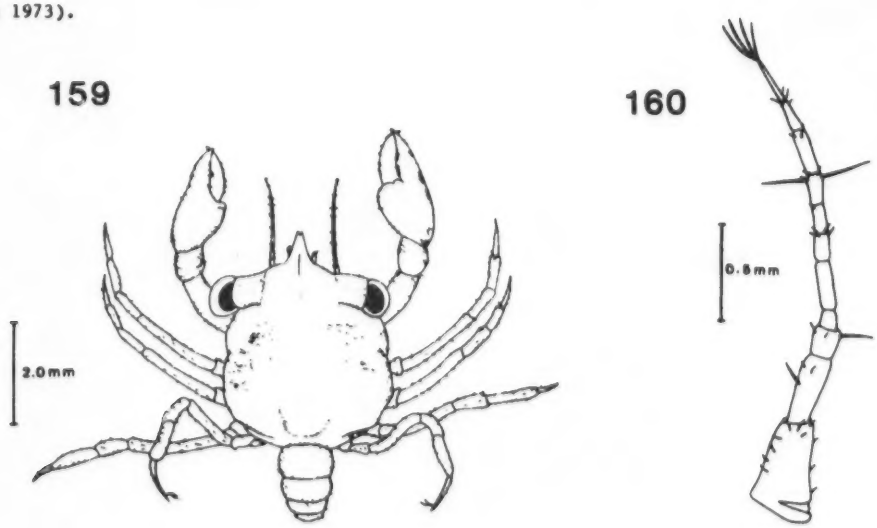
25b. Rostrum tip bifid; antennae without such long setae on any segment (Fig. 159, 160) . . . . . Geryon quinquedens Smith, 1879

Carapace length - 4.2 mm.

Fig. 159-160 Geryon quinquedens, megalopa.

Fig. 159. Dorsal view.
Fig. 160. Antenna.

(After Perkins 1973).



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APPENDIX 1. CLASSIFICATION OF THE DECAPODA: WITH MAJOR REFERENCES TO LARVAL FAMILIES AND SPECIES.

Order Decapoda
General larval characteristics - Gurney (1942), Williamson (1957)

Infraorder Anomura
1. General Anomuran characteristics - Williamson (1957)
2. Dromidia antillensis - Rice and Provenzano (1966)
3. Galathea rostrata - Gore (1979)
4. Lithodes maja - Pike and Williamson (1959)

Infraorder Brachyura
Section Gymopleura
Family Raninidae
1. Lyreidus bairdii - this text

Section Oxystomata
Family Calappidae
1. Calappa flammea - Goy (1979, pers. comm.) this text, Lebour (1944)
2. Cycloës bairdii - this text, Lebour (1944)
3. Hepatus epheliticus - Costlow and Bookhout (1962a)

Family Dorippidae
1. Ethusa microphthalma - this text

Section Brachyrhyncha
Family Cancridae
1. Cancer borealis - Sastry (1977a)
2. Cancer irroratus - Sastry (1977b)

Family Geryonidae
1. Geryon quinquedens - Perkins (1973)

Family Grapsidae
1. Planes minutus - Hyman (1925)

Family Ocypodidae
1. Ocypode quadrata - Crane (1940)

Family Pinnotheridae
1. General review of family - Hyman (1924)
2. Pinnotheres chamae - Roberts (1975b)
3. Pinnotheres maculatus - Costlow and Bookhout (1966b)
4. Pinnotheres ostreum - Sandoz and Hopkins (1947)

Family Portunidae
1. General review of family - Rice and Ingle (1975a)
2. Arenaeus cribrarius - Sandifer (1972)
3. Bathynectes superba - Roberts (1969).
4. Callinectes sapidus - Churchill (1942), Costlow and Bookhout (1959), Costlow (1965), Hopkins (1944), Naylor and Isaac (1973)
5. Carcinus maenas - Rice and Ingle (1975b)
6. Ovalipes ocellatus - Costlow and Bookhout (1966c)
7. Portunus sayi - Lebour (1944)
8. Portunus spinicarpus - Bookhout and Costlow (1974)

Family Xanthidae
1. General review of family - Wear (1970)
2. Neopanope texana sayi - Chamberlain (1961)
3. Neopanope texana texana - McMahan (1967)
4. Panopeus herbstii - Costlow and Bookhout (1961b)
5. Rhithropanopeus harrisii - Chamberlain (1962), Connolly (1925), Hood (1962)

Section Oxyrhyncha
Family Majidae
1. Chionoecetes opilio - Haynes (1973), Ito (1968a, b), Kon (1967), Kurata (1963), Motoh (1973), Davidson (1983)
2. Hyas araneus - Christiansen (1971, 1973)
3. Hyas coarctatus - Christiansen (1973)
4. Libinia emarginata - Johns and Lang (1977)

Family Parthenopidae
1. Parthenope pourtalesii - this text, Lebour (1944)
2. Parthenope serrata - Yang (1971)

APPENDIX 2: ALPHABETICAL LIST OF SPECIES INCLUDED IN THE KEY WITH NUMBERS OF DEVELOPMENTAL STAGES. (? = NOT KNOWN; (U) = UNDESCRIBED).

Species	Number of zoeas	Megalopa
Arenaeus cribrarius	Z1 only described (?)	(U)
Bathynectes superba	5 (?) + prezoea[a]	(U)
Calappa flammea	(U)	1
Callinectes sapidus	6-8, usually 7	1
Callinectes similis	6-8, usually 7	1
Cancer borealis	5 + prezoea	1
Cancer irroratus	5	1
Carcinus maenas	4 + prezoea	1
Chionoecetes opilio	2 + prezoea	1
Cycloës bairdii	(U)	1
Ethusa microphthalma	(U)	(U)
Geryon quinquedens	4 + prezoea	1
Hepatus ephelíticus	5	1
Hyas araneus	2 + 1 prezoea	1
Hyas coarctatus	2 + 1 prezoea	1
Libinia emarginata	2	1
Lyreidus bairdii	(U)	1
Neopanope texana sayi	4 + prezoea?	1
Neopanope texana texana	4	1
Ocypode quadrata	(?)	1
Ovalipes ocellatus	5	1
Panopeus herbstii	4	1
Parthenope pourtalesii	(U)	(U)
Parthenope serrata	5-6	1
Pinnotheres chamae	3	1
Pinnotheres maculatus	5	1
Pinnotheres ostreum	4	1
Planes minutus	(?)	1
Portunus sayi	(U)	(U)
Portunus spinicarpus	7-8	1
Rhithropanopeus harrisii	4	1

[a]Hatching into a prezoea before zoea 1 may be a result of unfavorable conditions. This molt may occur while in the egg.

APPENDIX 3: ANOMURA

Several species of Anomura can be expected in the plankton of the Scotian Shelf region. In zoeal stages they can be readily distinguished from the Brachyura by the following characteristics (see Fig. 5, 11, 14, 15):

1. Carapace has a stout forward pointing rostral spine (not ventral pointing).
2. Carapace has two postero-lateral spines (not lateral spines).
3. The telson is broad and flattened (not finely forked).
4. Uropods are present in later zoeas (absent in Brachyura).
5. A flattened antennal scale bearing 8 or more setae may be present (absent in Brachyura).

As megalopas, two species frequently encountered on the Scotian Shelf may be Galathea rostrata and Dromidia antillensis. Anomuran megalopas can be readily distinguished from Brachyura by the following characteristics (see Fig. 95, 96, 97):

1. Body is generally more spiny and/or setose than in Brachyura.
2. Antennae are generally larger and have more segments than in Brachyura.
3. Uropods are well developed (absent however in Lithodes maja).

For complete descriptions of some Anomuran species see:

Galathea rostrata - Gore (1979)
Dromidia antillensis - Rice and Provenzano (1966)
Lithodes maja - Pike and Williamson (1959)

Neolithodes grimaldii is not described in larval stages.

APPENDIX 4: MAJIDAE

For other species of the family Majidae which may occur around or south of Georges Bank as adults see: Rathbun (1929), Williams (1965, 1974b) and Williams and Wigley (1977).

Other published descriptions of zoeas and megalopas in this family on the east coast of North America include:

Anasimus latus - Sandifer and VanEngel (1972)
Epialtus dilatus - Yang (1968)
Libinia dubia - Sandifer and VanEngel (1971)
Mithrax forceps - Wilson et al. (1979)
Stenorynchus seticornis - Yang (1976)

APPENDIX 5: PINNOTHERIDAE

A combination of features sets pinnotherid zoeas apart from others (Rice 1980): (1) exopodite of antenna vestigial or absent; (2) two-segmented endopodite of maxillule with naked proximal segment; (3) endopodite of maxilla with three setae; and (4) two-segmented endopodite of maxilliped 2 with naked proximal segment.

For other species of the family Pinnotheridae which may occur around or south of Georges Bank as adults see: Rathbun (1918), Hyman (1924), Williams (1965, 1974b), and Williams and Wigley (1977).

Other published descriptions of zoeas and megalopas in this family on the east coast of North America include:

Dissodactylus rugatus - Pohle (1984)
Dissodactylus mellitae - Hyman (1924)
Pinnixa chaetopterana - Hyman (1924)
Pinnixa sayana - Hyman (1924)
Pinnotheres holothuriae - Hyman (1924)
Pinnotheres pisum - Hyman (1924)
Pinnotheres veterum - Hyman (1924)

APPENDIX 6: GRAPSIDAE

For other species of the family Grapsidae which may occur around or south of Georges Bank as adults see: Rathbun (1918), Hyman (1925), Williams (1965, 1974b) and Williams and Wigley (1977).

Other published descriptions of zoeas and megalopas in this family on the east coast of North America include:

Sesarma cinereum - Costlow and Bookhout (1960)
Sesarma reticulatum - Costlow and Bookout (1962b)
Pachygrapsus marmoratus - Hyman (1925)

APPENDIX 7: XANTHIDAE

For other species of the family Xanthidae which may occur around or south of Georges Bank as adults see: Rathbun (1930), Wear (1970), Williams (1965, (1974b), and Williams and Wigley (1977).

Other published descriptions of zoeas and megalopas in this family on the east coast of North America include:

Eurypanopeus depressus - Costlow and Bookhout (1961a)
Hexapanopeus angustifrons - Costlow and Bookhout (1966a)
Leptodius agassizii - Costlow and Bookhout (1968)
Menippe mercenaria - Porter (1960)
Menippe nodifrons - Scotto (1979)
Neopanope packardii - Costlow and Bookhout (1967)
Neopanope texana texana - McMahan (1967)
Pilumnus dasypodus - Sandifer (1974)
Other genera from Bermuda - Hyman (1926), Lebour (1944)

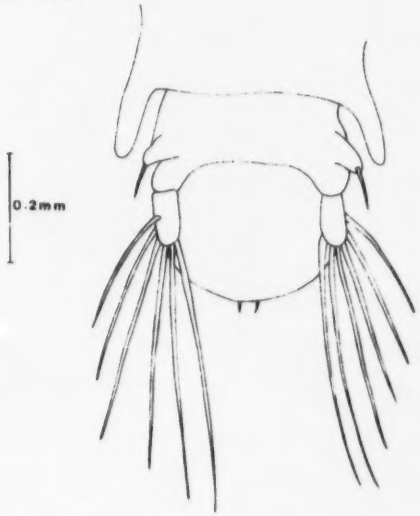
APPENDIX 8: NEOPANOPE TEXANA SP.

The subspecies of Neopanope texana likely to be encountered in Atlantic Canada is Neopanope texana sayi. Larvae of Neopanope texana texana are described by McMahan (1967) and those of N. texana sayi by Chamberlain (1961).

The differences between the two subspecies are very slight. McMahan (1967) reports that the megalopa of Neopanope texana texana bears three setae on the posterior border of the telson (Fig. 149), whereas Neopanope texana sayi has only two setae in this position (Fig. 161).

The zoeas of the two subspecies are extremely similar and have not been satisfactorily differentiated.

Fig. 161. Telson of Neopanope texana sayi megalopa. (After Chamberlain 1961)



APPENDIX 9: CALAPPIDAE

For other species of the family Calappidae which may occur around or south of Georges Bank as adults see: Rathbun (1937), Williams (1965), and Williams and Wigley (1977).

Most species of Calappidae are still undescribed as zoeas and megalopas. Lebour (1944) gives drawings purporting to be Calappa flammea and Cycloës bairdii as megalopas only.

APPENDIX 10: PORTUNIDAE

Several different species of larval Portunidae, especially in the genera Portunus and Callinectes as well as in other unidentified genera of this family, have been collected from the Scotian Shelf region. Larval stages of many species in the family Portunidae are not yet described.

Even within the described species there is difficulty finding reliable distinguishing characteristics. A combination of telson setation, antennal setation and body size may be useful in distinguishing these species. Zoeas of subfamilies Carcininae, Polybiinae and Portuninae can be recognized by a combination of characters (see Rice 1980). The described species of Portunidae which may be encountered are referenced in Appendix 1.

For other species of the family Portunidae which may occur around or south of Georges Bank as adults see: Rathbun (1930), Williams (1974a, b), and Williams and Wigley (1977).